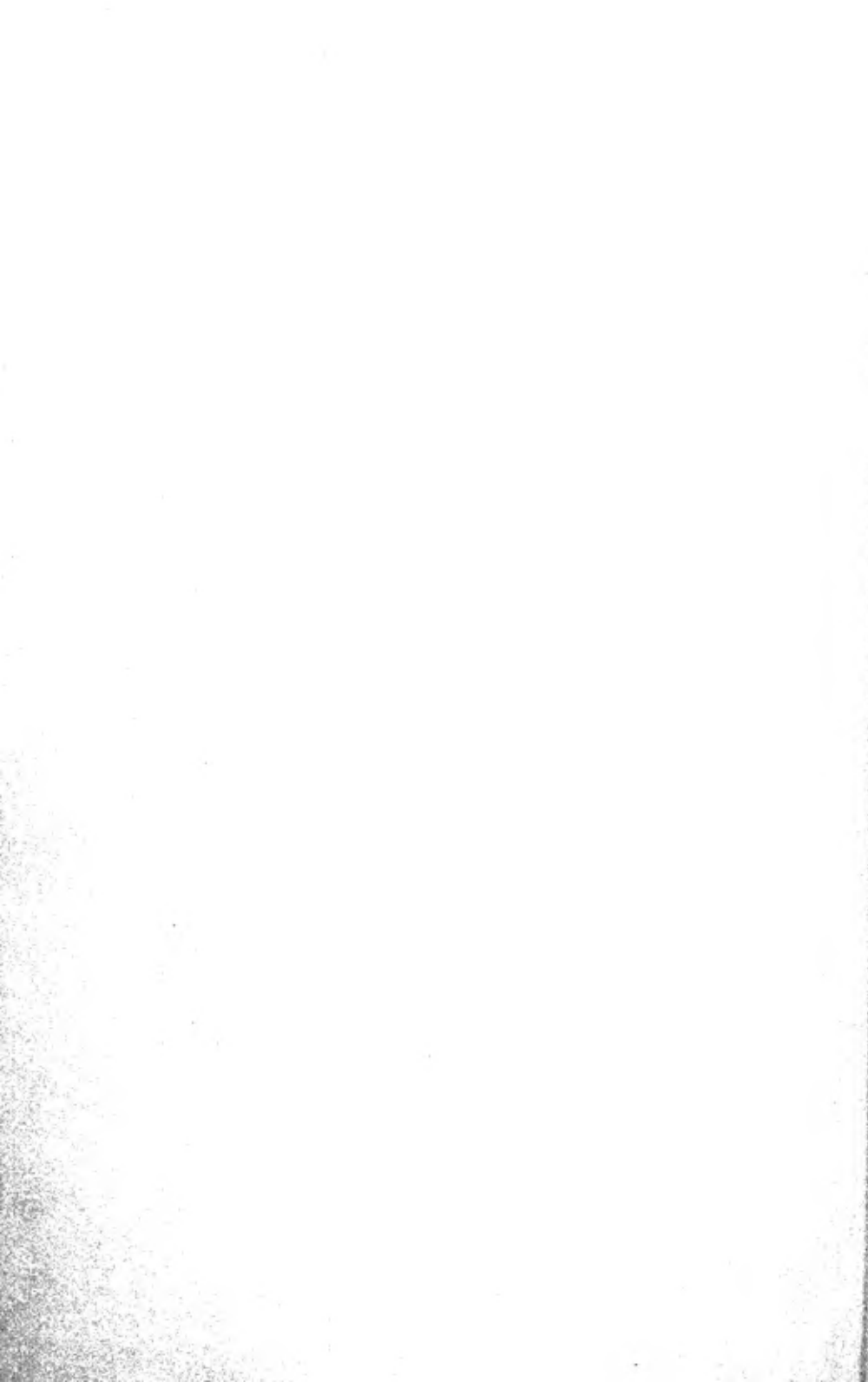


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The Story of Our Ancestors

Who was the first man? In this clearly written and profusely illustrated book, May Edel presents a survey of all the attempts that have been made to answer this fascinating question. She describes the clues, found all over the world, that have led anthropologists to the brink of discovering the final link between Ape and Man, and thereby providing the elusive answer.

by MAY EDEL

The Story of





Our Ancestors



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To my mother

by the same author

THE STORY OF PEOPLE

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The Story of Our Ancestors



1.

FOSSILS ARE CLUES

*I*T was an early morning in the winter of 1938. Gert Terblanche was on his way to the little country school he attended at Kromdraai in South Africa. He was thinking only of how to make the familiar walk less tedious. Was there time to leave the regular path that he followed day after day through the long school year, and cut across country instead? Gert thought of the fine handful of pebbles he could pick up at the top of the rocky hill that lay between his father's farm and the Kromdraai school, and decided to go that way. Perhaps if he was lucky, he would get a chance to shy a few of the pebbles at some unwary rabbit foolish enough to cross his path.

It was an ordinary walk to school on an ordinary day, but it led to something that wasn't ordinary at all.

When Gert reached the top of the hill, he stumbled, and his boot scuffed against a piece of stone embedded in a large mass of rock. When he bent down to look at it, he had no idea that he had stumbled upon a major scientific discovery—one that would get his name into newspapers all around the world. But he did think the little stone was odd enough

to be rather interesting. It looked exactly like part of the jaw-bone of a skeleton, even to the teeth. Carefully, Gert hammered away at it with another stone until he could break it away from the rock in which it was embedded. Then he tucked it into his pocket and hurried off to school. He had no time to show it off then, because now he really was late! But at lunchtime he took his trophy out proudly, to show to the other boys. He could have made a good trade for it then and there—a penknife, perhaps, or a new ball—but he decided to keep it for just a little longer. Plenty of time to trade it later on.

Or better yet: a really good idea struck him. Why not take it to the curio shop at Sterkfontein? The manager of the limestone quarry there often sold odd bits of stone as souvenirs to the tourists who came up from Capetown to see the great limestone caverns. Gert knew the place well. He and his friends often worked there as guides when there was no school. So the very next Sunday Gert walked over to Sterkfontein, taking the stone jaw with him, and offered it for sale to Mr. Barlow at the shop.

Mr. Barlow bought it all right, but fortunately for science he didn't put it out for sale in his little museum curio shop. If he had, some tourist might have bought it for a paperweight, and no one would ever have heard of it again. Instead, he put it aside to show to the curious professor from Capetown who so often dropped in to see if any interesting old bones had turned up at the mine. For once Barlow had something really unusual for him.

Professor Robert Broom was a paleontologist, a student of old bones. When he examined the pieces of stone Mr.

Barlow showed him, he was very much excited. To him, they were more than just odd-looking or unusual: they looked like something scientists had been searching for around there for more than fifteen years. He gladly paid several pounds for the specimen, but he insisted upon knowing just where it had been found. Barlow was reluctant at first, but finally he told of Gert's part in the discovery. Broom hurried off at once to the Terblanche farm. Gert was away at school, so Professor Broom followed him there, and found him playing out in the yard during a recess period, quite unaware that he had stumbled upon an important key to the riddle of man's past.

"Where are the other teeth?" Professor Broom demanded of Gert, scarcely bothering to introduce himself.

Sheepishly, Gert dug into his trouser pocket. He knew what Professor Broom meant, because when he had sold the "curio," he had broken off some pieces to keep for himself. He had been carrying them about in his pocket, along with more usual boys' treasures like marbles and pieces of string. Professor Broom had seen that at least two teeth had been freshly broken off. But Gert was able to hand him not just two teeth, but four—what Broom called "probably the four most valuable teeth in the history of the world."

That afternoon the school called a special assembly and Professor Broom explained to Gert and his classmates why these teeth and the stone jaw were so interesting.

Some years before, the owner of the mines, advertising the associated caves as a tourist attraction, had written in a pamphlet, "Come to Sterkfontein and find the missing link."

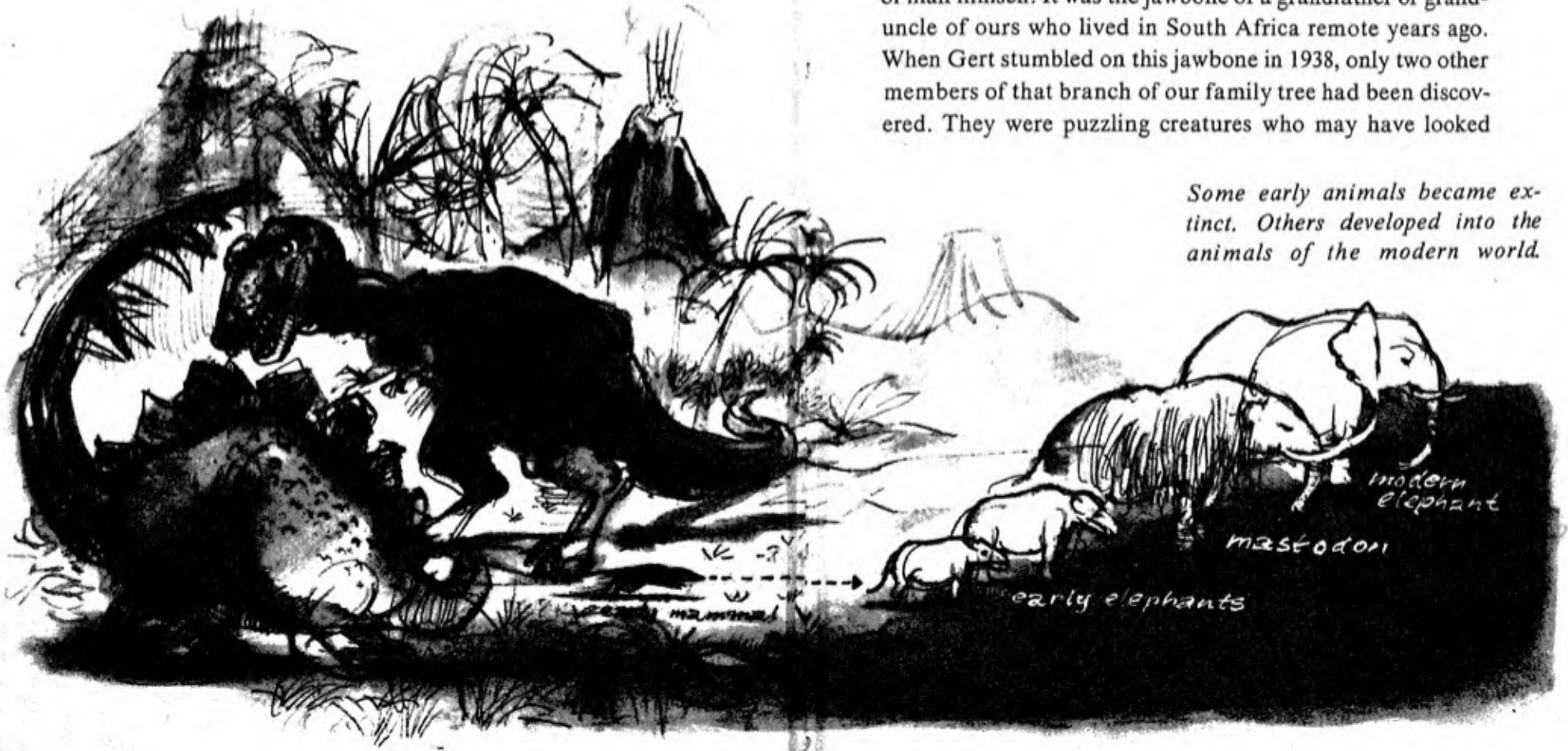
And that was exactly what Gert had done. He had found the fossil remains of a creature that lived thousands upon thousands of years ago, a creature that was not yet human, but that had already started on the long hard climb toward becoming a man.

Fossils are often the remains of creatures that no longer exist—extinct animals like the dinosaurs. But not all fossils are remains of animals that have disappeared completely. Some of the creatures of the ancient worlds before our time, instead of just dying out, gave birth to children and grand-

children who were a little different from themselves. As conditions in the world changed, they changed too, and so they were able to survive. These were the ancestors of the living creatures of today. Their fossil remains tell us what today's animals once were like, and how they took on their modern forms. They tell us the strange true stories of "How the deer sprouted its horns," or "How the bear lost its tail," or "How the horse grew from a four-toed creature no bigger than a dog."

Gert's fossil was more interesting than any of these. For it was not just part of a camel or a horse—but of an ancestor of man himself. It was the jawbone of a grandfather or granduncle of ours who lived in South Africa remote years ago. When Gert stumbled on this jawbone in 1938, only two other members of that branch of our family tree had been discovered. They were puzzling creatures who may have looked

Some early animals became extinct. Others developed into the animals of the modern world.



something like chimpanzees or young orangutans, but who walked about on the ground on their hind legs, with their heads in the air—like us. The jawbone that Gert had found would help to tell their story, and so to round out a chapter in our history—"How man came down from the trees and learned to walk erect."

This was the story that Professor Broom told Gert and his classmates that afternoon. No doubt all the schoolboys around there have been very literally watching their steps since then. None of them has yet been rewarded with another discovery. But Gert and the professor went back that very afternoon to the spot where Gert had found the jawbone, and there they found a few more pieces of this fossil ancestor, whom Professor Broom was to give a long Latin name, and tell about to all the world.

Perhaps it may seem very surprising to you that Professor Broom should make so much out of so little. After all, Gert had not found a large collection of human skeletons. All he had found was part of one head. These pieces were valuable because they fitted in with other bits of information. They were small pieces, but they were part of a big story—the important but puzzling story of man's beginnings.

Finding out how man began is like solving a great jigsaw puzzle. Today some sections of this puzzle have been worked out quite neatly, but in other parts there are still great empty spaces, or a few scattered pieces that don't quite interlock. It is only in the last few years that even the framework and the general outlines have begun to come clear, so that they really can tell the story of our past.

This book is going to tell that story, as far as it is known today. It is a long-ago story that goes farther back than any of the familiar "Once-upon-a-time" tales. It goes back before the days of King Arthur and his knights, back before the days of Cleopatra or Helen of Troy, back before Egypt and Babylon, back even before the days of the cave men. It is the story of the first men who lived on earth, and the almost-men who lived before them. And it is the story, too, of how the pieces of the puzzle that tells that story have been discovered, and how they are fitted together.

What kinds of people were the men who lived on the earth tens of thousands and hundreds of thousands of years before we were born? Did they look like us? Was there a time when men did not walk so erect as we do today, when they could not yet talk, when their bodies were covered with their own fur rather than with the skins of other animals? And where did the first men come from? Was the ancient cradle of mankind in Asia or Africa, or perhaps scattered through many parts of the globe? Were man's ancestors once upon a time creatures like the gorilla and the chimpanzee? If man developed from other, lowlier creatures, how did he learn to talk and think and behave so differently from the rest?

To discover the answers to these questions, men have dug carefully in the earth, looking for the bones of our ancestors of long ago. Others have studied the bones to find out what these ancient men looked like. Scientists have worked like detectives, trying to work out exactly how long ago the bones were buried, and when their original owners died. Men have gone out into forests and jungles to bring back specimens of our great ape relatives. They have even taken gorillas and

chimpanzees into their homes, so that they could watch their behaviour more closely.

Finding the pieces is the first big task, and it has come about in many ways. Great scientific expeditions have found some of the pieces; others have been discovered through the long, patient work of single men. A professor from Heidelberg examined the debris from a stone quarry near his home almost every day for nearly twenty years before he was finally rewarded by finding a single piece of a fossil early human jaw. And quite often luck has played a part, as it did that day Gert decided to take his now famous short cut.

The whole harvest of really ancient human fossils is still a pretty small one. All of it could probably be fitted into one room full of museum cases. And up to about thirty years ago almost all of it came from Europe. All there was besides was part of one lone individual from Java. Although Africa and more of Asia are represented today, there are still gaps in the record, and every scrap that is discovered has to be made use of.

It isn't really surprising that there are so few fossils in the record. In the first place, there weren't many men in the world in the very long ago. When man was just beginning to get a foothold on the ground, and learning to use tools and weapons instead of teeth and claws, he had a pretty tough time of it. He had to compete for living space with animals far stronger and swifter than he. Bears and hyenas wanted the same caves to live in; he had to fight them off, or perish. He could eat roots and fruits and capture small animals at water holes—but such a food supply could support only a tiny population in any one place. All the people of

those very early days weren't more than a few scattered handfuls compared to the world of today.

What is more, not many of the men who lived and died long ago ever turned into fossils. That isn't the normal fate of any kind of bone. Quite the contrary. Bones are much more likely to be gnawed up by other animals, or just to crumble into dust with the passage of time. Only once in a while does a bone happen to lie for years and years in a quiet spot where it is protected from animals and sheltered against weather and decay.

Sometimes this happens when an animal gets caught in a tar pit or in quicksand. This holds it and preserves it at the same time. Animal fossils are often preserved in this way. But not men. Even almost-men were too smart to be caught in such danger spots very often. Occasionally, though, men have been buried for many centuries, and longer, in the lava and ash from a volcanic eruption.

The most usual place for human remains to be found is in old limestone caves, for here, if the bones were not molested, there was a good chance for them to turn into stone. The slow dripping of water, droplet by tiny droplet, would deposit small specks of minerals in all the cavities and hollow spaces of the bone, until at last the bony substance was all filled up and perhaps even replaced by minerals that could harden into solid stone. That is why scientists who are deliberately looking for early human fossils often choose limestone caverns and quarries for their search. But even then, luck must be with them, or they will look in vain.

Fossil remains of early men are hard to find because there never were very many of them in the first place. But there's

another reason, too. Not all the human remains that once were preserved in some rocky bed are just lying quietly in wait for the careful spade, the whisk broom and delicate fingers of the experienced fossil hunter. Many valuable fossil remains are buried where we cannot possibly get to them, and many, many more have been destroyed. As Mr. Barlow, the mine manager in South Africa, said when he heard what the scientists from the university were looking for, "Oh, that sort of stuff! Why, we've been shoveling stuff like that into the kilns by the bushelful." Men have built their roads and cities without stopping to see whether any old bones lay buried in the rocks they were blasting out and casting aside.

Only recently, workers in Minnesota nearly threw away one of the oldest skeletons ever found in America. They were shoveling away at the side of a cliff, and saw what looked like an arm bone sticking out. They were interested enough to try to get it out, but not interested enough to bother to go after it when it fell out and down onto the pile of debris at the foot of the cliff. Fortunately, some of them talked about the incident afterwards, and it came to the ears of an archaeologist who happened to be in that region. Mustering a few assistants, he set to work sifting through all the rubble. He found not only that arm bone, but other pieces of an ancient skeleton as well. True, they weren't hundreds of thousands of years old; no man has been in America that long. But they were many thousands of years old, as old as any other human remains that have ever been found here. If the archaeologist hadn't just happened to be nearby, they would have been lost forever.

No wonder Gert's fossil find was so valuable. All remains of human ancestors of long, long ago are valuable, for they help to fill in the parts of the puzzle that still are incomplete.

But that doesn't answer certain other questions I'm sure you would have wanted to ask Professor Broom that afternoon in the little school in South Africa. How can anyone tell how old fossil bones really are? How do you know what some ancient creature looked like when all you have is a skull or jawbone, one or two bones, or some teeth? And how do you know where the creature fits into man's family tree once you do know what it looked like?

To find out how science answers these questions, and builds up a fairly reliable picture of man's ancient past from the scattered bits of evidence at its disposal, we're going to have to find out things from many different kinds of scientists. There's the biologist, who studies animal life generally, and can tell us something about our bodies, how they work and how they grew. There are paleontologists, who study old bones and their history; geologists, who work with the ages of the earth and of rocks and the fossils that are in them; anatomists, who work out details of how bones and nerves and muscles work together, and of how men and apes differ from each other. It is the anthropologists who try to put all this material together, to find out what they can about man's past—not just as ancient history, but because man's past can tell us something about what we are, and even give us clues about what we may become.

2.

THE STORY IN THE BONES

A great deal of the record of man's past is written in the fossil remains of our ancestors, like the ones that Gert Terblanche discovered on the hilltop at Kromdraai, near Sterkfontein. That was greeted by newspaper stories announcing, "Missing Link No Longer Missing," which, in a sense, were quite true.

And yet—what Gert had found had not been a whole skeleton, but only a few bones. How could Professor Broom tell what it was? Many of the other parts of the fossil record are also just fragments—a skull and a thighbone, perhaps, or a few skulls. What can science really tell us if this is all there is to go on? How much of a story can a bone really tell us?

Of course, Professor Broom was not going just by the fragments at Kromdraai. He was comparing them with modern man, and with other apelike forms. And he was comparing them with other finds in South Africa, forms which had been the subject of a great deal of discussion and argument.

Fortunately, with such comparative material available, a few bones can really tell quite a story.

You see, a bone is not just a random bit of stiffening set in the midst of a mass of flesh and gristle. A bone is part of the machine by which an animal moves. It is connected to muscles which push it and pull it, and it is linked onto other bones with which it forms different kinds of joints. Every bone has a definite shape and a definite set of connections with other bones and muscles. It follows a pattern that was laid down aeons and aeons ago, when animals first began to have bones. Most differences since then have been just variations and improvements on the pattern, not fresh starts. Because of this it is possible to compare the bones of different animals and find out a great deal about what the living animals looked like, and how they moved.

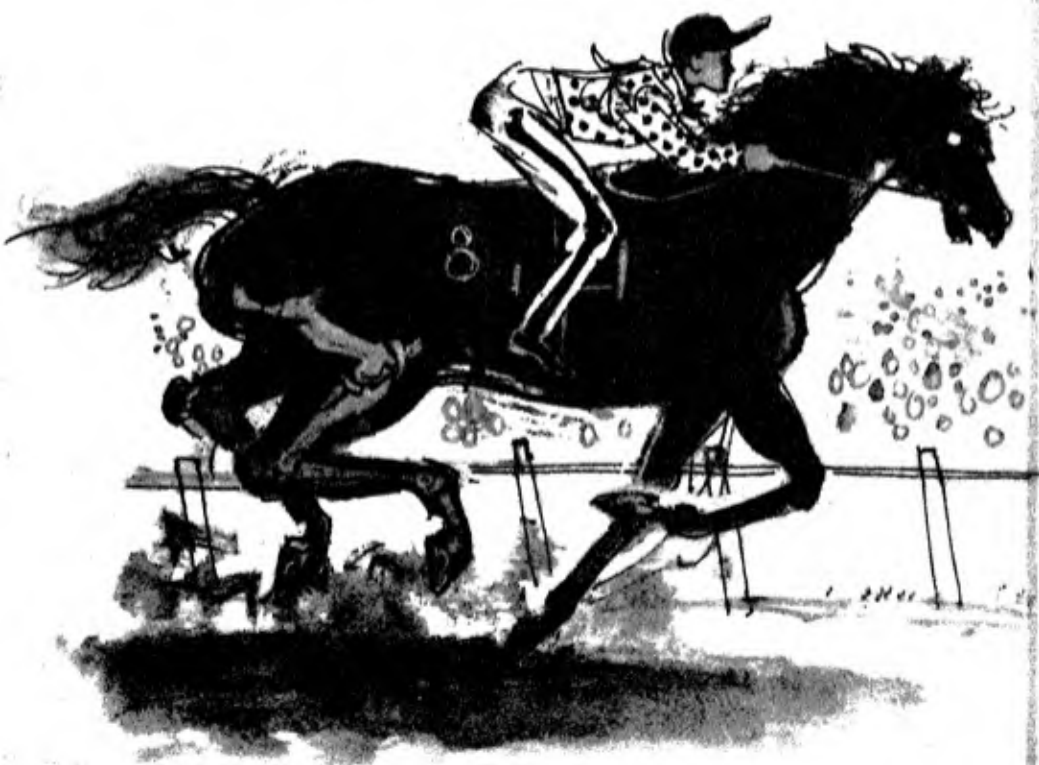
There's nothing mysterious about this. You yourself can learn to recognize the main bones by their general shape. I don't suppose you have a convenient human skeleton in your closet, but you can easily get parts of other animals. You might start with an upper leg bone. That's a good one to get acquainted with because it is very sturdy. It survives as a fossil more often than most. The bone from a ham or a leg of lamb will be fine if you can get one, or even the thighbone from next Sunday's chicken dinner will do to start with.

Be sure you get hold of the right bone. The thighbone is the "second joint," not the drumstick. The drumstick corresponds to your lower leg. And the long scaly part of the chicken "leg"—the part the butcher usually throws away— isn't part of the leg at all. It is actually part of the foot! The chicken uses its feet quite differently from the way we use ours. It walks on its splayed-out toes, and the rest of the foot, instead of resting flat on the ground, stretches upward. Lots

of animals walk that way, with their heels way up in the air. Dogs walk on the padded balls of their feet, and horses just use the tips of their toenails!

Because animals use their feet so differently, their lower leg bones do vary a little. We have two bones in our lower leg. You may even know their names, the tibia and the fibula. But if you look at the chicken's drumstick, at first sight it seems to have only one.

Two bones in the lower leg is what the basic animal ground plan calls for. This allows a certain amount of flexibility, so



*Our leg bones and those of other animals
are variations of the same basic arrangement.*

that the foot can rotate a little. In fact, for feet that work as ours do it allows a little too much rotation. We have heavy tendons to correct for this, but we still suffer from sprained ankles pretty easily. Animals that are swift runners and jumpers, like horses or rabbits, kangaroos, even emus and chickens, would be very much inconvenienced by this flexibility. In such animals, the little second bone that provides for easy rotation has usually grown very small. In the horse, it has disappeared altogether. It's fused right in with the main lower leg bone. As a result, a horse can't move his feet in different directions; it's even hard for him to sit or lie down, as you may have noticed. But the sturdier fused bones help give his legs more reliable strength and speed. In the chicken, the second bone is really there still, but you'll have to look closely to find it. It's just a tiny splinter attached alongside the main bone of the drumstick.

Now let's get back to that thighbone, or femur, that you rescued from the kitchen or the butcher's shop. Thighbones are a little more alike among different animals. The same general description will fit whichever one you have there—chicken or lamb or pig—and it will also fit you (or me!).

You'll find that the thighbone is a sturdy hollow column, with flaring ends. One end has a groove between two swellings. The flat top of the lower leg has a corresponding bulge in the middle, so that it interlocks at the joint like an ordinary hinge. The lower leg can swing smoothly back and forth in this groove—but not sideways. To keep it from swinging too far forward, strong tendons—like heavy piano wire—

hold it in place. If the bone you are looking at is fresh from the butcher shop, you may still see some of these tendons attached to it. The ordinary meat is muscle fiber. This too must be attached to the bone. Muscle fibers are elastic, and as they stretch and shrink they pull the end of the bone to which they are attached. That's how you bend your knees, or move any other part of your body.

The upper end of the thighbone also has two parts, but they don't match. One side is rough and bumpy; the other is a perfectly smooth round ball. In you and me and some of the other animals this ball sticks out at an angle from the main bone. This ball fits neatly into a cup in the hipbone. It forms a ball-and-socket joint which allows motion in all directions—like one of those lamps that pivots into any position. Again, muscles and tendons attached to the bones hold them in place and move them.

You may notice that the joint ends of the bone look very smooth and shiny. That's because there is a moist protective coating on all joints to keep them moving smoothly, just as oil lubricates the moving parts of a man-made motor. Animal-joint lubrication is factory sealed and doesn't need renewing, but it tends to dry up with old age, and then the joints get creaky.

Once you've had a good look at a thighbone, you will probably recognize one easily anywhere. It won't surprise you that the scientist can say, "This is the thighbone of an animal, of about the same size as man." But the scientist usually says more than that. For example, he may say, "This thighbone tells us that its owner must have walked erect, like a man."



He can do that because the bone as part of a living machine has clearly marked on it the kinds of uses to which it was put. Compare the way the chicken holds its leg, for example, with the way you hold yours. Your legs stretch straight down from your hips, continuing the line of your vertical backbone. The chicken's leg is tucked tightly in under his body, at a sharp angle to his backbone; which is more or less parallel to the ground. Naturally, to be anchored comfortably in that position, the ball at the end of his thighbone has to be set at quite a different angle from yours. Also, tendons and muscles hold his thighbone more tightly in line: his leg doesn't swing as freely as yours does. Rough places and bumps on the bone show just where and at what angle the different tendons and muscles were attached when the animal was alive and walking about.

Your thighbone has its round ball jutting off at a high



backward angle. Down the back of the bone is a long sharp ridge. This is for the attachment of the very heavy muscles coming from the buttocks. The length and thickness of that ridge show how strong and well developed these muscles are. They have to be, to keep us upright and moving. Your legs have a very complicated athletic feat to perform: they have to balance your flexible backbone, and shift the balance every time you step forward, like a juggler with a cane balanced upright on his hand. Only the cane is flexible—it's made of twenty-four separate blocks, very loosely tied one on top of the other, and quite given to swaying, though not to falling apart.

No wonder balance requires three hundred different muscles, over a hundred of them in the lower leg.

The bumps and ridges your legs need will not be the same as those of a creature that uses its legs differently. Even the legs of your close relative the chimpanzee do

not have the heavy ridge down the back that your legs have. He does not support himself in an upright position all the time; his buttocks and upper leg muscles are very small. On the other hand, his arms and shoulders have much heavier muscles than yours, and this would show in the bones of those parts.

These are the kinds of landmarks and clues the anthropologist works with when he studies a skeleton, or part of a skeleton, and tries to work out what the machine of which it was a part was like. By comparing the landmarks on various bones, especially the upper legs and the skulls, which are all that he usually has to work with, he can tell whether the creatures they belonged to were upright or stooping, whether they walked on the ground or lived in the trees, and so on.

Even teeth can tell a surprisingly full story. The teeth of different animals vary a great deal with their food and eating habits, and even with their ways of defending themselves. The teeth of a cow, for example, have heavy ridges running back and forth on the grinding surfaces of all the back teeth, so she can grind and grind away at her peculiar diet of grass and hay. Dogs have long, sharp, rending teeth for killing their prey. Human teeth have their own special arrangement which we share with some of our close animal relatives. You can expect to have the same number and arrangement of teeth as your neighbour (or a chimpanzee) when all your teeth are in—two biting front teeth, an eye-tooth, two bicuspid and three molars, or grinders, in each half of each jaw. (On the other hand, you may never get that third molar—the so-called wisdom tooth—because it often fails to come out in the tiny crowded jaws of us nonchewing

soft-fed moderns.) It's not just a matter of the number and arrangement of the teeth being the same. If you look at the chart in your dentist's office, you'll see that the diagrams of the various teeth have little marks on them. These show the location of certain bumps and the hollows between them. The dentist uses these to mark the location of every cavity and filling in your teeth. He can use the same diagram for all of us because the bumps and hollows on our back teeth are all alike. They are so alike that a specialist can use them to recognize whether a particular tooth is human or not, and to see whether a fossil tooth belongs to a preman, or to a creature rather more like the great apes than like ourselves.

By now you won't expect to find whole skeletons in our story as it unfolds, and you will be able to understand how a headline, "Missing Link Found in Africa," or "Early Man Discovered in China," can be based on just a few bones or a few teeth: You will also see that the stories these fragments tell have to be read carefully. They give lots of facts, but they can't tell everything.

It certainly would have been more convenient if early man had left us some nice full-length portraits of himself. We can't very well expect ape-men to have left us rock paintings and engravings as later, more fully human, cave men did. But we can hope for something in the fossil line that will do that kind of thing, a fossil that will record the outside of the animal rather than just the bony inside. Such fossils are possible. I recall once seeing a sign in a small Connecticut town that read, "Dinosaur footprints for sale." That sounds like a simple hoax on an unwary tourist, and perhaps it was. But

fossil footprints do occur, and right in the Connecticut valley. They tell us some of the important parts of the early story of animal evolution.

How can soft parts of an animal be preserved as fossils? The shape of a foot, or the outlines of a leaf or a tiny insect body may be stamped on mud, which holds the imprint as it hardens. This forms a kind of mould, exactly the shape of the object that made the impression. Sometimes this hollow fills with mud which dries up and hardens, and this is what is left for us. In that case, we have a cast of the original object. There's nothing mysterious about these processes. You did the same kind of thing any time you made a papier-mâché puppet head by moulding the wet paper around a ball, or filled a rubber mould with wet plaster to make a statue, or pressed the pattern of your fingers into clay.

It would be nice to have such a footprint of man when he was just learning to walk, or the mould of a full face, showing the mouth and nose formation. It could have happened, if some individual had just been obliging enough to have died with his face in a fast-hardening mud or clay pit, just soft enough to take the impression and hold it. So far we have just one such windfall, the cast of the brain and part of the face of a very ancient South African child.

What about the statues and paintings that one sometimes sees, labelled *Pithecanthropus*, or Neanderthal man?

When a scientist makes such a painting or statue, it is only meant as a guide to the layman to help him visualize the basic general characteristics of the creature. It isn't an exact reconstruction. Of course, it is not just made up out of whole cloth. The scientist is guided by indications in the bones

about what the soft parts were like. Heavy ridges on the back of the head mean that heavy muscles were attached here, for holding the head up. Modelling the head of such a form, the sculptor will give him a thick heavy neck, almost no neck at all, like the giant ape forms of today. A smooth round skull will mean that the head was well balanced, without needing such heavy support, and will suggest that the creature had a slender neck, like man today. So that is the way the sculptor will model him. But at some points he just has to use his imagination, and we have to use our critical discretion not to take the result too literally.



Skeletons, like athletes, tend to get their noses broken rather easily, because nosebones are fragile and delicate. So neither an artist nor a scientist can tell usually if a fossil man or an ape-man had a Roman nose or a turn-up one. Nor whether he had a friendly grin or cupid-bow lips. But, for-

tunately, lower jaws and foreheads are a little sturdier, so he can tell more readily if Mr. Ape-Man X was a lowbrow or had a dimpled chin.

There are some parts of the story bones can't tell at all. Bones can't tell us whether the living creature they once belonged to was furry or smooth-skinned, whether its hair was curly or straight, black or brown, or perhaps bright red like that of the orangutan. They can't tell us whether its eyes were blue or green or dark brown. And bones are the same colour no matter what colour their owner's skin happened to be. A reddish or yellowish colour in a fossil bone doesn't mean it belonged to a reddish or yellowish animal, nor even anything special about some peculiar mineral content of the original bone. Rather, it tells us something of the material in which the bone was buried, and sometimes it can provide a valuable clue to how long it lay there. But the colour may also come just from some preservative like shellac brushed onto the fossil to keep it from falling to pieces in the air!

The main parts of a skeleton can certainly tell a pretty full story, if they are read carefully. But what about just pieces of bones, the broken fragments that are sometimes all that there is to go by? Are they any use? Can positive statements be made about the size and shape of a head if only part of it is found? Surely those must be guesses!

The great anatomist Sir Arthur Keith was once challenged this way, not just by laymen but by fellow scientists. He was the leading authority on the reconstruction of the skull from fragments. He would work from specific landmarks, like the places on the skull where the separate bones of the

infant skull join together as the individual grows. These joining places can be seen on the bone, and even on a fossil, as long zigzag lines. Using such landmarks, Keith could put four or five pieces together in their correct relation to each other; just as when you work on a jigsaw puzzle, if you know you are working on a picture of a person standing, you will put parts of the eye in place toward the top, and shoes way down, and make various other connecting points meet accurately, even though there are some gaps and holes.

"Prove that your method is really correct," said the challengers. "When you put together pieces of some ancient fossil head, we can't tell whether you've succeeded in making it come out the way it should. Suppose you try your skill on pieces of a head we all can recognize, and have seen."

Sir Arthur accepted the challenge. The doubters selected a skull that was rather unusual in a number of ways. They measured it in all directions, and they photographed it from all angles. Then they broke it up and sent Sir Arthur just four pieces of the bone. They were from about the same parts of the head as the pieces of a famous fossil skull Sir Arthur had reconstructed. Working with his usual care and skill, Sir Arthur put the skull together again. He identified it correctly as a woman, and it came out to just about the right size and shape. The challenge had been successfully met.

Of course, though such things can be done, it is always possible to make a mistake. That is why in most cases, when there are only fragments to work from, the identifying and reconstructing are done independently by several scientists, so that any possible difference in interpretation will come to light.

Working by such techniques, scientists have been able to figure out what quite a number of our ancient grandfathers and great-grandfathers were like. Using the bits and pieces of bone, the whole skeletons, and the scattered teeth that they find in the paleontologist's fossil warehouse, they have identified and described various nearly human ancestors you are going to meet—the ape-man from Africa, Neanderthal man, and the almost-men from Java and China. Some can be labelled fully; others have large question marks attached to them still. And a few are just kept as showpieces. They are examples of past mistakes kept as warnings for the future.

But in order to put all these pieces together into a story of man's past, anthropologists need to know more than what each of these creatures looked like. They also need to know when each of them lived, which came before and which later. And they need to have a theoretical outline of man's ancestry to see how each new pieces fits into the picture, or changes it.

Just as anatomy helps to work out what our fossil ancestors looked like, geology is called in to help to say how old they are, how long ago they lived, and in what sort of environment. Let's see what tools are at hand for this part of the anthropologist's job.

3.

READING THE TIMETABLE

How old is a fossil?

Strictly speaking, fossils don't have to be old at all. Fossils are just "those things that are dug up." And many significant things are dug up that aren't so very old. Just recently, for example, the body of an Inca girl who lived before Columbus was found frozen solid in a cake of ice. It was absolutely intact. This was a valuable "fossil" find, even though it was only hundreds, not thousands, of years old, and it hadn't been turned into stone.

Usually, however, the fossils we're interested in are very old indeed—at least by everyday standards. There are fossil remains of people exactly like us who lived on the earth tens of thousands of years ago. And the fossil remains of almost-men and ape-men go back much further than that.

If the anthropologist wants to find out when "modern" man began, or which of our fossil ancestors came before which, he has to know how to date fossil remains.

He can't go just by the condition of the fossil, by how thoroughly it is turned into stone, or by its colour. These things vary too much with conditions of soil and weather.

There is a famous example of a "fossil" horse dug up in North Africa that had turned into stone within a human lifetime. It was identified by the markings on its horseshoes.

Most fossils are buried in layers of rock on the earth's surface. When the anthropologist wants to know how old they are, he asks the geologist, "How old is this rock layer my fossil is buried in?" But that isn't an easy question to answer.

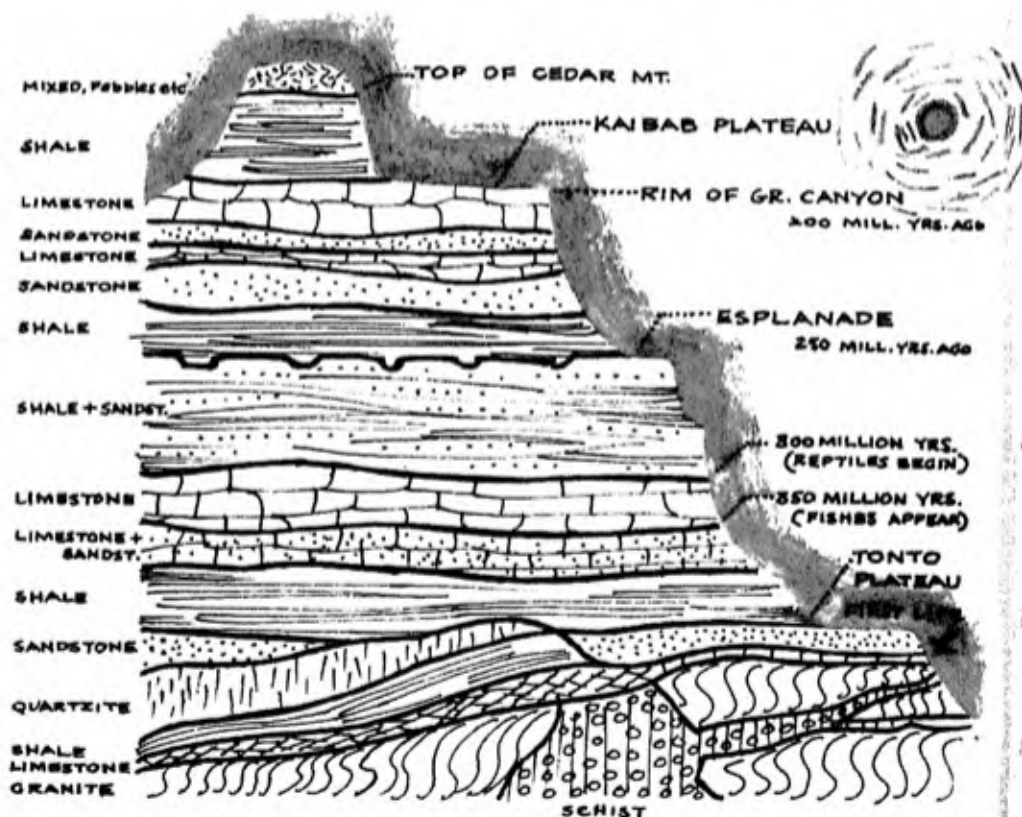
Most of the earth's surface is made up of many layers of different kinds of rock. There is the original crust of the earth, the granite that hardened as the earth's surface cooled. Then, as the ages passed, wind and water wore this down in many places and carried the debris as sand and gravel to other parts of the earth's surface. Here the sand and gravel hardened into layers of rock that lay on top of the original crust. After life began, living things added their substance, and mud and soil formed still other kinds of rocky layers.

Each of these layers tells the story of the earth as it was in its day. Limestone beds tell of seas full of shellfish. Hardened mixtures full of gravel speak of river beds and seashores. Coal and oil deposits tell of great prehistoric forests. And fossils in any layer tell of the animals and plants of their day, and so, also, of earth and weather conditions.

From the arrangement of the rock layers on various parts of the earth's surface, the geologist reconstructs the history of the world. Usually, the oldest rocks are at the bottom, and the layers above are the ones that were laid down as the ages passed. But the arrangement isn't always perfect and tidy. Mountains have been born in great upheavals of the earth's surface, more terrible than any recent earthquakes. These have tilted some of the layers sideways—like a slice

of cake that has toppled over. And in some places, erosion has eaten away more recent layers, leaving the more ancient past once more exposed. Sometimes it even happens that the only way the geologist can date a particular layer of rock is by the fossils that are in it—if he is lucky enough to know their age from some other part of the world.

Geologists are pretty well agreed about the main events in each area. They tell us that much of North America was covered by an inland sea at fifteen different times in its past, and that the Appalachians are vastly older than the Rocky



These are the various rock layers in part of the Grand Canyon. The more recent ones—at the top—have all been worn away. Fossils are found in many of the different layers.

Mountains. They can usually disentangle the various layers and work out a comparative timetable which reads upwards like the layers of the earth from the time the crust first hardened, long before life began, up to the present.

But working out actual dates to go with the sequence is quite another matter. Here there isn't such universal agreement, but perhaps it will come as new methods are worked out. Recent developments in physics and chemistry promise fairly accurate and uniform results. For example, by studying the chemical composition of the basic rocks of the earth's surface, and computing the amount of time it takes a given amount of uranium to break down into lead, scientists have discovered that the original rocks of the earth's surface are fully two billion years old. That gives at least one margin of minimum common agreement.

Unfortunately, this method is not much use as yet for dating *fossils*, because they aren't found in the bedrock, but only in various places *on* it. They are the remains of *living* things, and life didn't begin till hundreds of millions of years after the earth cooled down.

A related, but somewhat different method is being used now that helps to date more recent layers quite exactly. This method is known as *Carbon 14*. It is based on the knowledge that living things absorb radioactive carbon; after life is gone, this radioactive carbon is slowly dissipated. With a Geiger counter, it is possible to measure the amount of radioactivity still present, and so to compute the length of time since the plant or animal died. For example, charred coals in a hearth fire have been dated as twenty-three thousand years old. As it happens, the amount of radioactivity present after about

twenty-five thousand years is so tiny that present instruments can't detect it. But with technical progress moving ahead as it has been, this handicap will surely be overcome.

Meanwhile, there is a big gap that can only be handled by estimates. For example, how does the geologist know how many million years it took for the rocky sides of the Grand Canyon to be built up, or for how long the Colorado River has been cutting its way down through them to form the present gorge? He uses techniques such as counting the layers laid down year by year along the shores of an ancient lake, which sometimes show up quite sharply, and computing how long it took for one foot to be formed. Or he makes a comparison based on processes going on today which he can measure over a given number of years. Sometimes, though, his estimates in years or millions of years can only be very rough ones, subject to change as more perfect methods are worked out; or he may not even attempt to give an age in years. When the anthropologist asks his geologist colleague to date a fossil for him, he very often gets an answer like, "That fossil belonged to a period at the end of the age of reptiles," or, "This one lived when the glaciers were moving southward over Europe for the last time."

This sort of dating—most often all that the fossil hunter has to go by—is what is called a "relative" timetable, not an "absolute" one. That is, it doesn't tell how old a fossil is in years, but only, "This kind of creature is older—or younger—than that one," or belongs to a certain period in the world's history which has a name though not an exact date.

Naturally, the relative timetable has many hazards. For example, there was a great to-do not long ago when some

spear points were found in America in connection with the skeleton of a mastodon. Spear points mean man. Everyone had been saying that man had come to America only in comparatively recent times. But the mastodon, an elephant-like mammal, became extinct a very long time ago. Did this mean that man had a much earlier history in America than anyone had thought? At first, that seemed the only interpretation that could be put upon it. Even newspaper headlines appeared on the subject. But if you think about it, you'll realize there is another possible explanation. And it is the



BEFORE

Dead pterodactyl



AFTER

His fossil remains

one which is now recognized as correct: the mastodon did not die out as early in that part of America as had been assumed, or as was true in other parts of the world. So man could still be a newcomer here—twenty or twenty-five thousand years old—and yet have lived here with the mastodon.

This kind of dating has other hazards, too. You have to be very careful to take exact note of just where the fossil you dig up actually was buried. If you're at all careless about it, you can mix up the rock layers and so disturb all the evidence of dating. And you have to make sure that your fossil is lying in the place where it died, and not in a spot deep down under, where it was buried. You have to watch out for bones washed out by river or rain ages after they are originally deposited in or on the earth, for then they may be jumbled together with bones of very different ages.

It's questions like these that make the scientists so fussy about doing the digging themselves. They want to do it gently and carefully, not with spades, or with speedy bulldozers, but with little hand shovels and their fingers, a small sieve, or perhaps a delicate little paintbrush to brush off the surface dirt.

Recently a young British chemist, Dr. Kenneth Oakley, has revived a method for working with fossil bones which avoids some of the pitfalls of the old dating techniques. It's still a "relative" method, but a somewhat safer one. It was first suggested many years ago, but somehow never put into use until now. Dr. Oakley's method measures the amount of a chemical deposited in the fossilized bones during their years in the ground. The chemical is fluorine—the very

chemical that is added to the water supply by many cities nowadays to help preserve young people's teeth from decay. No doubt it has something of the same effect in preserving fossil material.

In utilizing his method, Dr. Oakley has to know, of course, just where a fossil bone came from, and how much natural fluorine there is in the waters of the region. So far, it is useful only for comparing the bones in one region with each other. It can separate older from more recent bones, even though their later history threw them together into one resting place, or they were unburied carelessly without noticing their original resting place. But it can't compare the ages of bones buried in quite different regions.

Using this fluorine method, Dr. Oakley has been able to establish that some of the fossil skulls and other bones found in England are quite ancient. For example, a skull found right under the City of London, in an excavation being dug for a huge new building, was as ancient as the building was new. It was a real modern man, who must have looked just like us—but the skull was twenty, or perhaps even thirty, thousand years old. And there was another early Englishman—or Englishwoman—who lived even longer ago, but unfortunately didn't leave us enough remains to tell us much about herself.

Oakley's methods have had another, very much publicized, consequence. They have solved a problem that had been causing a great deal of difficulty and confusion in all the accounts of human evolution, the problem that centered around the Piltdown man. Oakley's solution caused a real

sensation. It made newspaper headlines for days. For his work revealed that what had looked like a scientific puzzle was not a genuine puzzle at all. In fact, the discovery wasn't even a discovery. The Piltdown man that scientists had discussed and worried about for nearly fifty years had just never existed in the first place!

The Piltdown skull was found by a lawyer, one Charles Dawson, way back in 1908. Dawson was an amateur paleontologist, fascinated by old bones, who spent all his spare time exploring the countryside near his home, hoping to come upon remains of ancient man. One day he was excited and delighted to find a piece of skullcap protruding from the ground in a chalky deposit where workmen were doing some excavating. Being just an amateur, and knowing how important it was that all details of the actual digging-up be carefully done and accurately noted, he got in touch with Arthur Smith-Woodward, a professor of anatomy at the British Museum in London, and persuaded him to come down to Sussex to help with the excavating, and look for possible other pieces. He wanted to be quite sure to make no mistakes that would lessen the scientific value of his discovery.

Together, Dawson and Smith-Woodward explored and dug and sifted, and together they brought to light a strange combination of pieces that was to plague anthropologists for years to come. For what they found were some pieces of a head; thick-boned, but quite modern in all its other characteristics, and a lower jaw, together with some loose teeth, that were far more apelike than those of any other ape-man or man-ape fossil. The pieces were all stained dark brown by mineral deposits. They exactly matched all the other ani-

mal fossils that were found in the same neighbourhood, and some of these were the remains of animals that had been extinct for hundreds of thousands of years.

How was this mixed-up picture to be interpreted? Did man develop a human brain in England long before he did anywhere else, long before the rest of his anatomy had caught up with it? That idea may have been gratifying to patriotic English souls, but it didn't fit very well with what biologists could reasonably expect. Could it be that the parts didn't belong together? That seemed too great a coincidence altogether, for how could an ape and a man have died together so conveniently, been of just the right sizes to fit together, and left only exactly matching traces—no two jaws or two foreheads? The coincidence seemed especially unlikely since there weren't any other remains of any other individuals: no other evidence that apes had roamed that part of the world at all, in those days.

Some students made great efforts to fit these confusing pieces into the story of man's development, and to figure out some kind of creature that could have had such different-looking head and jaw parts. Others just said frankly that they couldn't make any real sense out of this part of the puzzle. They decided to push it aside and leave it for later on—just as you no doubt have often done with some confusing corner of a jigsaw puzzle.

One man, however, refused to accept any interpretation of these pieces; he felt that they didn't belong in the picture at all. This man was Franz Weidenreich. You will meet him later on, putting together important other pieces of the puzzle. Weidenreich looked at the remains from Piltdown and

said, "This is *exactly* like the jaw of an orangutan. Therefore, it *is* the jaw of an orangutan. No amount of argument can make it something else."

And so the matter stood—until one day in 1953, when Dr. Oakley set to work to recheck the Piltdown results with his fluorine method. Then the story came out—the story of a scientific hoax—the most successful scientific forgery of modern times.

Some time earlier, Dr. Oakley had discovered that the skull of the Piltdown remains appeared to be old, but not nearly old enough to belong to a remote missing link. It was tens of thousands of years old, but not hundreds of thousands. It was more recent even than the time of the cave men in France and Spain. How then was it possible for it to be associated with such an apelike jaw? Oakley decided that he would have to tackle the jawbone itself. So he set to work to drill a tiny hole in it in order to remove a sample of the material from deep inside for chemical analysis.

No sooner had his drill bitten into the body of the bone than Oakley became very suspicious. Something very curious was wrong with this "fossil"! For the smell given off by the dust his drill made was not just a dry odor one would expect from stone; it was the odor of ordinary old bone. And suddenly it all became clear—the ape jaw was not a fossil tens of thousands of years old, like the skull. It was just the jawbone of a modern orangutan which someone had very skillfully altered so that it looked as old as the skull and matched it in color and shape. It had been stained brown, and some of the teeth and other parts had been very carefully and delicately filed down so they wouldn't be too obviously apelike.

And, of course, the most critical parts, the parts where the skull and jaw would hinge together, were missing—not just by accident, as everyone had thought, but because these parts would not have fitted together properly and so would have given the whole thing away.

The forgery had all been done so skillfully that it had fooled not only the people who studied pictures and models of the finds, but even many scientists who had handled the originals. Weidenreich was right; it was the jaw of an ape. But there was no puzzling coincidence; someone had simply put it there.



Oakley's drill biting into the piece of "fossil" Piltdown jawbone

But who? And why?

It certainly wasn't done for money. Was it for glory, or was it someone's strange idea of a joke? Perhaps Scotland Yard will have to take over and solve the whodunit angle. Could it have been Dawson himself who devised the hoax? He is certainly the most obvious suspect. But the evidence is only circumstantial. And how could he, a lawyer and an amateur, have had enough knowledge of anatomy to make the alterations even if he wanted to? What about the expert he called in to make sure his finds were authentic? He is a very reputable scientific figure; it is libellous to think of him in such a role. Who then . . . ?

As a mystery the case of the Piltdown hoax is still unsolved. But the case of Piltdown man as a scientific puzzle is settled. All the leading anthropologists agree that it must have been forgery, and so there aren't any more awkward pieces to be fitted into a puzzle where they just wouldn't fit.

The *New York Times* told the story under a headline that read, "Experts Redfaced on Piltdown Hoax." Now if the story had come out through someone's confession, or by the sharp work of some detective, it would really have been most embarrassing for science. But that is not how it happened. It was revealed through the careful work of a scientist going about his normal business. And so the story is not embarrassing; it is gratifying. For it shows how in the march of science new methods correct old mistakes. Scientists had been uncomfortable because these pieces of the puzzle somehow seemed out of line. Now that messy corner is cleared up. And clearing up this confusion leaves the rest of the picture of man's past far neater, far completer, and far more

dependable than it could ever have been with these unsolved pieces lying about.

Meanwhile, the routine work goes straight ahead. Without worrying about headlines, scientists concentrate on the search for facts and their meanings.

Although the techniques are rough, and mostly just "relative"—that is, they give only later-than-this-but-earlier-than-that results—the general outlines of man's place in the whole picture emerges pretty clearly. It is obvious that we humans, and our fossil nearly human ancestors, are quite recent inhabitants of the world. All the manlike remains are to be found in the topmost of the geologists' rock layers—modern times, and the period of the ice ages that came just before—in all, a total of about a million years.

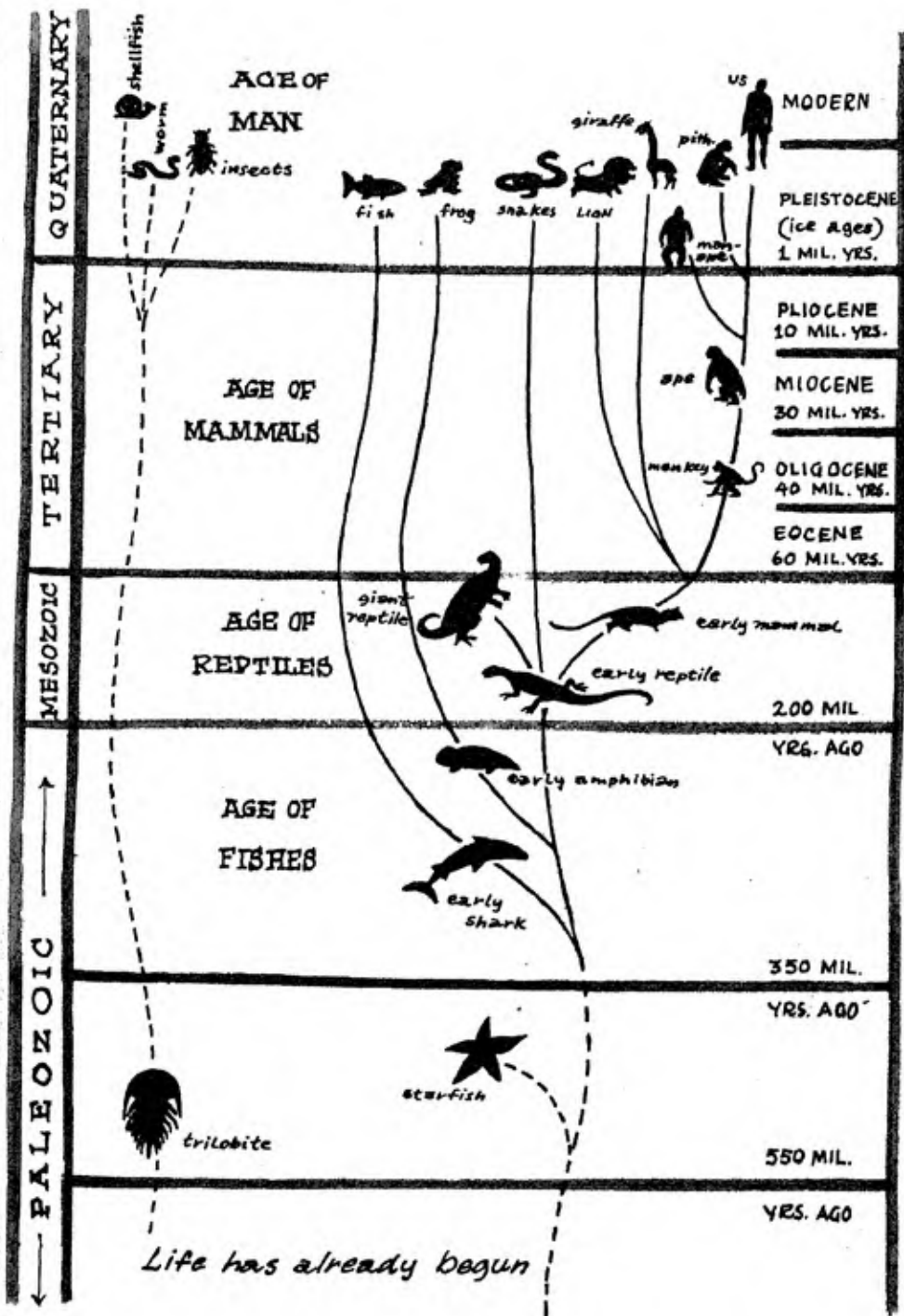
To the geologist, "modern times" go back about fifteen thousand years. During that time the world has been pretty much the kind of place we know today. The plants and animals, climate and geography of the world have remained about the same. Of course, man has introduced some rather drastic changes. We have domesticated some plants and animals, and killed off quite a few others. We have cut canals from sea to sea, tunneled under mountains, cleared away vast forests. But there have been no major natural changes.

Before modern times, though, the world was really quite different. Quite a long way back it was different in both climate and geography. The dinosaurs roamed in a world of unfamiliar plants and animals, a strange world of steaming jungles. New York was once a desert, and South America an island continent.

The "ice ages" were not quite so different. They go back only about a million years before modern times began. The main difference during that period was in the climate. At least four times during this last million years the earth grew colder, and great masses of ice were formed. These glaciers moved southward like great rivers of ice, till an icy cap covered the northern half of both hemispheres. And then, as tens of thousands of years passed, the earth gradually grew warm again. The ice masses melted and flowed back toward the extreme north. The climate of southern Europe and North America became as warm as today's subtropics. This process repeated itself over and over again.

Specialists in weather tell us that it takes only a drop of about ten degrees in the average temperature for such an icecap to begin to form, but the difference in the over-all conditions that result is very sweeping. During the periods of the glaciers heavily furred animals, cousins of the arctic forms of today, lived in the south of Europe. There was the mammoth, furrier cousin of today's elephant, cave bears and cave hyenas and a great woolly rhinoceros. Then in the warm interludes between glaciers tropical animals took their places, and great herds of wild horses roamed the grassy plains.

The first men who were altogether like us, early ancestors who were definitely human in every way, go back to the last stages of the ice age. And our somewhat less human ancestors are very much older. They dip way back into the early days of the glaciers. So far, the earliest carefully checked date for a fossil that is humanlike, though not yet fully hu-



man, is about a half million years ago, but scientists expect to find more primitive forms that are earlier.

As the evidence looks today, we can call the last million years the "Age of Man," for during all that time there were creatures on the earth who were taking definite steps toward becoming human. But these were just the final steps in a very long process. If we want to understand the groundwork upon which our humanness was built, we have to go back much further than the beginning of the Age of Man, for the first steps were taken long before man or any of his close relatives appeared on the earth.

4.

WHERE WE BELONG

*T*HE anthropologist uses the tools of the anatomist to study fossil remains like those Gert found in South Africa. That is how he finds that they walked upright just as we do, with their heads held high, and yet had brains far smaller than our own. He uses the tools of the geologist to try to determine their age. But with these tools alone he cannot tell how to interpret the results. Were these creatures men or apes? Were they our ancestors, or some strange offshoot of our family tree? How did the changes come about? And what happened before? If it was during the last million years that the finishing touches of man's special humanness were worked out—learning to walk upright, and growing a giant brain—where did the basic equipment come from in the first place, and how did it get to us?

The fossil material of the last million years is important—but it isn't enough. Fortunately, the anthropologist isn't altogether dependent on it.

It was Charles Darwin, about one hundred years ago, who worked out the idea that man was descended from an ape-

like ancestor. But when Darwin wrote his account, no one had ever seen an ape-man skeleton, nor even part of one. He worked out man's story without using human fossil material. And even the rest of his account of animal evolution, though it did have some fossils to go on, only used this material as one part of the evidence.

Darwin worked primarily by comparing living creatures. And that is still an important part of the method of solving the puzzle of the past.

This is how it works:

The biologist compares living creatures, and sees how much they are alike. Those who are most alike are, on the whole, most closely related to each other.

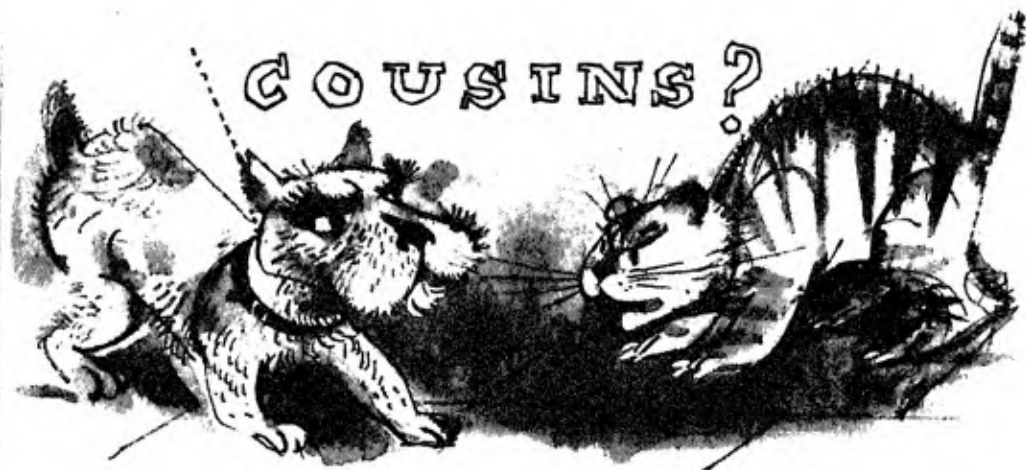
A cat and a lion and a tiger are close relatives. They are members of the cat family. And you don't have to be a zoologist to see that a puma or a leopard belongs in that family, too.

All the cats are meat eaters, with slashing teeth and flashing claws. And so are all dogs and wolves and foxes. Clearly, the dog family is related to the cat family, but it is a less close kinship. They don't have a common grandfather, but a common great-great-grandfather.

Lots more fossils have been found since Darwin's day. But the scientist still uses an outline picture based on comparing living forms. Without this he would not be able to interpret the fossil record. And, in its turn, the outline picture must stand the test of comparison with the fossil record.

Sometimes the fossil record holds surprises. For example, bears and dogs seem to be quite separate families. But one

C O U S I N S ?



day not so long ago a fossil hunter working with bear bones turned up a bear ancestor that wasn't a bear at all. It was very much like a dog. This means that bears and dogs are much more closely related than they look.

Usually the fossil record does support the biologist's outlines, and it fills in times and places. The common ancestor of dogs and cats, for example, lived some sixty million years ago. Those were the dawn days of the mammals, when the dinosaurs and other giant reptiles had disappeared, and the face of the world was changing. Wide grassy plains had grown up in place of the swamps and marshes and great fern forests of earlier days. New grass-eating animals were growing plump in these vast prairies, and the ancestors of all the modern meat eaters were learning to prey upon them.

They were developing the claws and teeth suited to such a hunter's life. Their modern descendants have changed in many ways, into the various dog and cat families of the modern world, but they have inherited the wonderful equipment their long-ago ancestors worked out.

Man's story has to be worked out in the same way. The study of man's place in nature must come first. Who are his relatives, and how does he resemble them? The biologist must start by charting a family tree of man's obvious relations. Only then can the fossil record be useful, to see how and where each branch developed, and what the basic steps were by which man finally came to be what he is today.

The biologist sees man as cousin to the apes, descended from a common ancestor. To understand this, we have to see ourselves as the biologist sees us—not as everyday ordinary people, but as biological specimens.

Let me introduce you to your biological self. Meet—*Homo sapiens*, Man the wise guy. That's our official name, and the biologist means it quite literally. We are "*sapiens*"—wise, or knowing—beyond any of the other animals. Only man is smart enough to build fires, to make clothing, or to talk sense, not just parrot words. (That doesn't mean everything we say always makes sense!)

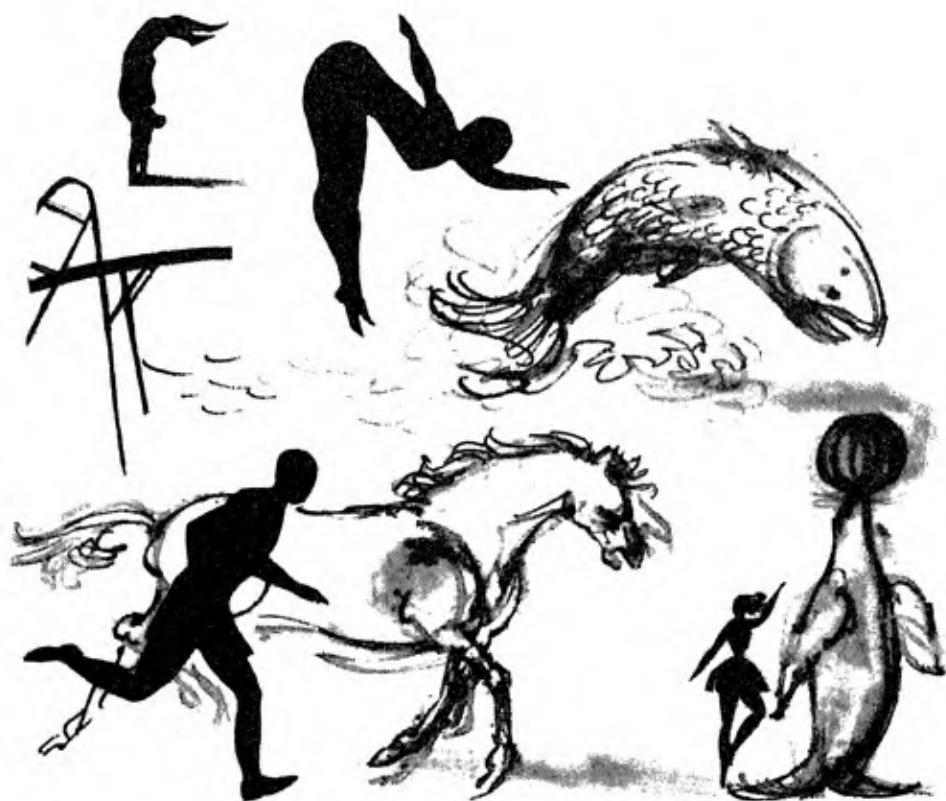
This animal "man" is quite odd-looking. He has long hair on top of his head and sometimes on his face, but the rest of his skin is almost naked. He has four limbs like most other animals, but he walks about on only two of them, with his body balanced upright very precariously. Man's legs end in flattened supports with a flexible arch that's supposed to

give his walk some spring. But this frequently breaks down. (No doubt a foot designed from scratch would work much better. The trouble with this one is that it's an adaptation of what was once a quite efficient kind of supplementary hand.)

This two-legged arrangement leaves man's forearms free of any job in locomotion. He doesn't need them for walking, and only occasionally uses them for swimming or climbing. Instead, he uses them for handling things. They are especially suited for this. The whole hand is flexible and can grasp an object securely. Each of the five fingers is also flexible and can move separately. The fingers can work with the thumb, which is set at an angle, and so can handle things delicately.

To top off this lanky body, man has a large round head, with an enormous brain, but a tiny, smooth, baby face. The face has no muzzle, but it has a peculiar bridge that juts right out over the mouth. And the lips and cheeks are full of muscles that are used for all sorts of grimaces and contortions.

Man's body is not only odd-looking, it can do some very odd things. And some of them are quite wonderful. We have sharp eyes both of which can focus on the same thing at the same time. That gives us splendid 3D vision—without spectacles! We can't smell as well as many animals, but we can see much better—more depth and form and colour. Our hands can do marvellous things, too—not just catch balls or wield a sledge hammer, but pick up single pins, and play the piano. And in spite of our peculiar posture, our ways of getting about are pretty skillful, and more varied than those of



other animals. A man can run nearly as well as a horse, climb nearly as well as a cat, swim nearly as well as an otter. And in addition, he can go through all the wonderful spins and turns and floating leaps of a ballet, slide down a banister, dive and turn somersaults.

Other animals can usually do one sort of thing supremely well, but they have lost other possibilities in developing their one specialty. Man, instead, has specialized in remaining flexible. Our giant brains can guide us through intricate



coordinations, and our bodies can perform all sorts of varied activities.

But in spite of all these special and unique characteristics, the biologist sees man as fitting right into a place in the whole pattern of animal life. Every animal is special in its own way, but each has its connections, its kinship bonds with other forms. And man is no exception. His body is a wonderful new model, but it is based on patents taken out a long time ago by other creatures—our long-ago ancestors.

Traced by the biologist, man's place in nature looks like this:

Man belongs in the animal kingdom. All living things are made of the same basic kind of stuff, called protoplasm. Protoplasm varies, but they are all made up of carbon and nitrogen and lots of other chemicals, built into little cells or blocks. Man is made of cells of protoplasm, like every other living creature.

All living things eat and grow and have children. Some can live on raw chemicals, but all the ones we call *animals*—large or small—including man—must live on plants or other animals. Man must go out after his food like any other animals, and he reacts as they do to signals of light and heat and pressure from the outside world.

The first animals were just one-celled creatures, perhaps not very different from the amoeba or the paramecium that you can see under the microscope swimming about in a drop of water. Then some cells grew together in little groups. At first each cell performed all the separate tasks of living; eventually in some of these little animal colonies the important discovery was made that it was more efficient to specialize. The outside cells began to concentrate on getting and sending messages, and on moving about, and the inside ones took care of digestion, and of producing offspring.

We and all the other many-celled animals in the world owe our complicated bodies with all their special organs to the lowly ancestors who first developed this design for living hundreds of millions of years ago.

Man is a vertebrate. We share the general ground plan of a great many other animals in the world. We have a head at one end, a brain that is the top end of a nerve cord that runs down our backs, and a skeleton of jointed bones on the inside of our bodies.

Perhaps that sounds like the description of just about any kind of animal, but it isn't. It fits the vertebrates—fishes and reptiles, birds and mammals—but it doesn't fit all the myriads of other creatures in the world. If you try to find the head end of a starfish, an oyster, or a snail, you'll see what I mean! And lots of animals like the shellfish that do have a kind of skeleton wear it like armour on the outside, instead of inside for support.

Many of the creatures without backbones developed quite wonderful devices, like the compound eye of the dragonfly, with its thousands of tiny facets to receive the light and build it into a picture of the world. But on the whole theirs was a dead-end line of development, and they had to move over and make room when the vertebrates developed. For



the vertebrate plan allowed for more growth and strength; the skeleton could grow with the animal; it was a support, not a burden. And the nerves were pushed back to a better position, so that the brain could grow without interfering with feeding and breathing.

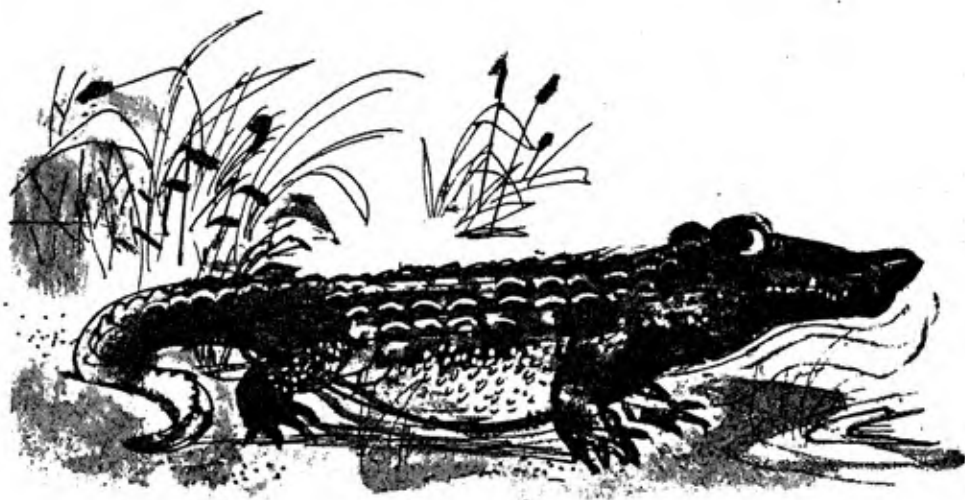
Man shares the vertebrate ground plan. And that means that he and all the other vertebrates are relatives: way, way back, we all stem from the same main branch of the tree of life, one that started a new line of development which all the fishes and reptiles and mammals—including men—have built on.

Man is a mammal. We belong among the warm-blooded furry animals, like the cats and the bats, the squirrels and the whales and the elephants. Almost all of us mammals bear our young alive, and feed them on mother's milk. We have wonderful thermostats for keeping our body temperature even—ways of sweating and flushing the blood to the surface to cool off, and ways of shivering to keep warm. We all have four-chambered hearts, to keep the fresh blood from our lungs separate from the old blood that has given up its food and oxygen in its trip around our body. We all have stomachs and livers and kidneys, salivary glands and thyroid glands and dozens of other chemical devices that are almost exactly alike. And we all have a basic four-legged skeleton, though some of us have changed it about in a good many ways over the years since the mammals began.

Man is exactly like the other mammals in all these ways. All of us mammals come from the same branch of the vertebrate stock. We all began some hundred million years

or so ago, in the days when the giant reptiles still dominated the world. The reptiles are vertebrates, too, but they haven't such a good internal heating system, and their brains are tiny pinheads compared to the mammals'. They are four-legged, too, but their legs aren't as efficient as the mammals'. Did you ever watch a crocodile or a turtle move? It lies flat on its belly with the legs sprawled like a queer splayed-out version of our arms and legs. When the turtle wants to move, he has to hoist his body up off the ground. If you've ever done push ups you know the kind of effort that's involved when you lie flat on the ground with your arms bent and then raise the front part of your body by straightening your arms out. And the reptile's body isn't even balanced on his legs; they're just sort of attached alongside. No wonder some of the large giant reptiles spent so much of their time wading and floating in the water!

When some cataclysm overwhelmed the reptiles sixty million years or more ago, the tiny but more efficient mammals were able to survive it; then they multiplied, and branched



out into all the many different forms and kinds of mammal families of the world. Some of them went on to become dogs and cats and elephants and whales. And some of them went on to become us.

To our vertebrate ancestor we owe the general outline of our bodies and the beginnings of our major organs. And we owe far more specific inventions to our mammal ancestry—our thermostats, our four-chambered heart, all the arrangements of our glands and our muscles, even the basic pattern of our eyes and ears and brains.

This was all part of the heritage on which our more immediate ancestors could build when they took their separate way among the mammals.

Man is a primate. Man's special kinship is with one particular family among the mammals. We cannot claim special kinship with the lion, however noble and kingly he may be, for we do not swish our tails nor kill and rend our foes with sharp slashing claws and scissor teeth. We are not horned and hoofed like the sheep and antelope and reindeer. Nor are we especially close to the bats that fly or the moles that burrow, or even to the beavers, who build great log dams as we do, but build them with their teeth. Our special kinship is not with any of these, but with one particular group among the mammals—the apes and monkeys.

We and the apes and monkeys are all members of one family—more technically, *order*—of mammals. We are alike, as cats and dogs are alike, or horses and cows, because we are *cousins*, all descended from the same original ancestor, way back in the dawn days of the mammals.

Our name *primate* just means *first*. It describes our idea of our position in the animal world. If we had been given a descriptive name instead, such as most orders of mammals have—the “meat-eating” carnivores, or “gnawing” rodents—we might have been called “the forward lookers” or “the big heads” or “the tree climbers with flat nails.” These are some of the traits we share with our primate cousins. We all have real hands, complete with neat fingernails. We all have big heads, with extra brain room, and eyes that face straight ahead rather than out at either side of a muzzle. When a scientist finds a strange animal in some odd corner of the world that has these characteristics, he can say, “Well, here’s a primate.” And he can do the same thing when he finds a fossil that has these traits.

While the ancestors of the horses and cows were growing their sturdy legs for speed, and ridges on their grinding teeth so they could live comfortably on the grasslands, and while the earliest carnivores were developing their hunter’s equipment, our own ancestors were taking to the trees. There they developed the special primate patents which were at last to lead to us.

5.

NATURE'S PATENT OFFICE

WE are going to look at the special primate "patents" and see how our ancestors first learned to live in the trees and then eventually remodelled their bodies for life upon the ground.

But before we do that, we have to straighten out this idea of "patents" and "inventions." These are very convenient words to use, but of course they must not be taken literally. It is true that from time to time during the history of animal life basic improvements made whole new ways of living possible. But these great steps forward weren't actual inventions, based on deliberate planning. The lungfish didn't sit down and work out a way to solve the problem of dry-land living, and then build a neat amphibian body to suit. Nor did the first mammals work out a careful blueprint for their thermostats, and then put it into operation. The actual process was a gradual one, of new variations that came about and survived because they were better than the old. The new were never built from scratch, but always by some modification of the old.

Biologists today can tell us something of how these changes take place. The raw material comes from heredity. Heredity usually means ways in which you are *like* your parents. It is true that we *inherit* our blue eyes or blond hair. But heredity isn't absolutely stable; from time to time, heredity also changes. Children will be like their parents on the whole, but in a large group a few will turn up who are a little different.

For example, in a population of ordinary grey rats all the children will be rats, no question about that. But a few will turn up which have shorter tails or no whiskers or a sprinkle of white in their coats. These differences are because of changes in *genes*, the hereditary particles that guide the animal's growth. Such gene changes are the raw materials of improvement. *Selection* works on this raw material. That is, if any of the changes that "happen" to come about make it better or easier for the animal to survive, the changelings will obviously live longer and have more offspring than the originals. It's easy to see this in cases of colour adaptation: a white creature will live longer in snow than one that is starkly black or mottled, because its enemies will not be able to see it so easily against the white background. Many white-coated creatures will therefore survive to hand on their genes for a white coat to the next generation. Meanwhile, the black-coated creatures and their dark babies will be easily seen against the snow and so be killed off by preying enemies. In time, individuals with the gene for dark coats will be wiped out of the population.

This isn't only Darwin's theory. Biologists have experimented in many ways and have actually seen it happen, on a



small scale. For example, they have painted barn floors black and watched the owls pick off the lighter individuals among the mice, until the whole mouse population grew dark-furred.

So far, however, biologists don't know just what makes these gene changes or *mutations* come about in the first place. They know that bombardment by X rays will make them turn up faster than they otherwise would; that is one of the known and feared effects of radiation. For while mutations that happen to be useful sometimes occur, and are the basis for the selection which results in evolution, many gene changes are

harmful, destined only to kill off the animals who have them. We will have to leave it to the biologists to work on this problem and find out why the genes change, why some forms are more plastic and change readily while others have remained the same for untold ages, how much change occurs in the genes and how much just in the body itself as the organism grows, as well as how quickly new or changed traits can spread through a whole population under various circumstances.

We can see the way whole populations do change in a very sharp and simple form if we look at the way a strain of insects reacts to DDT, or bacteria to penicillin.

The population of flies, let us say, subjected to DDT will for the most part be killed off. But some among them quite by chance happen to be resistant to DDT. This actually happened to a strain in Southern California. This mutation, which shows up once in a while in the ordinary fly population, has two effects. It not only makes the fly resistant to DDT, but it also happens to make him blacker. DDT killed off all but the individuals who were resistant to it—that is, all but the *black* flies. In mighty few generations there was a new population of flies, black and resistant to DDT.

This is a peculiar kind of “natural selection” because it’s so sweeping and so quick. The nonblacks didn’t just have fewer offspring. They were all actually killed off. But it points to two very important things that happen when natural selection takes place.

First, it isn’t an individual that changes: it’s the group as a whole. When we look for fossil “missing links,” we aren’t looking for a scientific substitute for Adam—some one early

ape that somehow had a human baby. We are looking for a group of not-yet-human ancestors that was changing through selection into a somewhat different form, one in some ways more like us.

And *second*, the gene changes have somehow to be already present in a population before selection can favor them. The DDT didn't *cause* the gene change. It just set the stage for flies with this gene factor to live, while the others died. And the fact that the flies that survived were black shows the way in which factors not in themselves valuable may happen to survive or increase because they are "linked" to useful genes.

Research will some day tell us what causes the changes in genes that make it possible for species to fit into new environments, to develop new forms. Meanwhile, we can only look at the results and see how man did in fact slowly develop from a simple early mammal through several clear stages of primate ancestry to his present status as *Homo sapiens*, mightiest of them all.

6.

OUR PRIMATE COUSINS

I should like to introduce you to your living primate cousins. This isn't just a matter of good manners—though, of course, a well-brought-up person always does recognize his poor relations, even after he has himself come up in the world. But in this case we have a further reason. The resemblances and the differences among us primates help to chart our family relations, and so give us the important first clues to our past.

The primate family is a pretty big one. It includes more than such familiar citizens as you and me and the apes and monkeys. If you go to the museum, or the primate house in a big city zoo, you will find other creatures there whom you have probably never even heard of. There are woolly animals that look like foxes with slender tails. The sign says these are lemurs. And there's a tiny fellow called a tarsier who's so peculiar you really have to see him to believe him. He has great staring saucer eyes, like an illustration for Andersen's "Tinder Box" story, and long spidery fingers. Each one is tipped with a big flat suction disc, just like the rubber ones you use to put clothes hooks up on the wall when you can't

drive in nails. And they're for the same purpose—the tarsier can hang himself up by them! As if these discs didn't make his hands queer enough, the middle finger of each hand has become a different household gadget; it stretches out like a long skinny piece of wire, very handy for digging juicy worms out of bark or wood.

A lemur or tarsier is pretty hard to accept as a relative. They don't look in the least like us. But they have to be included because they have some of the characteristics that are found only among the primates. Like us, they have nimble, flexible fingers that can grasp and handle things. Like us, they depend on vision rather than on smell for the cues that help them to get along in the world. And the tarsier even



This is a tarsier.

has traces of the expanded brain that is such a proud boast of man and the other "higher" primates. These strangest of our relatives give us a remarkably good idea of what some of our earliest primate ancestors were like.

The rest of our relatives are not nearly so strange. In fact, many people find it embarrassing to visit the primate house because so many of its ape and monkey inhabitants are just a little too humanlike. Some of the monkeys may be a little queer-looking, like the tiny marmosets with their tufted, pointy ears and fur ruffs. But most of the monkeys look very much like little gnomes—with their clever fingers capped with perfect fingernails as dainty as those of a human baby, their attentive eyes, and funny expressive faces.

Actually, there are two basic kinds of monkeys. The familiar monkey of the organ-grinder is one of the big family of South American monkeys. The monkeys from South America have long grasping tails that they can pick things up with or even hang and swing by. Mother monkeys use their tails to hold their babies safely on their backs. There are lots of different South American monkeys—spider monkeys with great long skinny arms and legs, who are real aerial gymnasts; tiny marmosets, no bigger than squirrels; and fierce-looking howlers, with large heads and faces, and a habit of scowling and showing their sharp teeth.

Because the grasping tails of these South American relatives of ours are so familiar, you may think that tails are characteristic of the monkey family generally. But they aren't. They're not found in the other branch of the family. The monkeys of Asia and Africa can't pick things up and carry things with their tails, but they have other interesting and

convenient developments of their own. One of these is a deep storage pocket inside the cheek. Some quite unrelated tree dwellers, like the squirrels, have such pouches, too. They're very handy devices for creatures who have to scamper out on swaying branches to find their food. They can stow fruit or nuts away in their cheek pouches and then run safely on all fours to some place where they can sit down quietly to eat. Cheek pouches are useful for tree dwellers but apparently they aren't absolutely essential. If they were, all our relatives would have them, and then perhaps we would still have them, too!

Another peculiar feature of Old World monkeys is something with a wonderful name. It's called an "ischial callosity"! And what it is is as wonderful as the name: it's a built-in, well-padded seat cushion. And in some monkeys, especially the baboons and their relatives, it's often highly coloured! (No slipcovers or reupholstery available though; you have to stick to the colour scheme you were born with.)

Baboons are pretty peculiar creatures altogether. They've given up their tree-living heritage and live on the ground, going about always on all fours. Their snouts are longer, too. They and their relatives the mandrills are coloured in a way we find among no other creatures but birds—wonderful vivid stripes of red and blue on their faces as well as on their seats. They're quite the most resplendent creatures—and almost the ugliest—you can imagine. They are social creatures who live in large troops, and are always reported to be extremely intelligent. But nothing complimentary is ever said about their manners and morals. There is no question about it—at least in captivity, the baboon is about as nasty, brutish, and selfish



*One of our Old World
monkey cousins*

MANDRILL

as an animal can be. The heads of the families are the old males, who collect numerous wives and keep the young men in a long state of enforced bachelorhood. They snatch all the food, allowing no one else to get a share until they are absolutely stuffed. They steal and cheat and get into all sorts of petty quarrels which quickly become free-for-alls that don't end until some of them are killed. However, this may be partly the result of laziness and boredom from being cooped up together in a zoo with no need to forage for a living.

These are our monkey cousins—intelligent and amusing caricatures of ourselves—but most of them are small creatures with long tails, and although they sit up straight enough, they do walk on all fours. Monkeys are our relatives. We and



they share many basic patents. But they aren't such close relatives as the apes.

The great apes aren't just another kind of monkey. They are different creatures entirely. Your zoo has lots of kinds of monkeys, but no matter how big it is, it has only four kinds of apes; that's all that are left in the world today. And it is these great creatures—the chimpanzee and gorilla, who live in the tropical forests of central Africa, and the gibbon and orangutan, who live in a tiny corner of southeast Asia—who are our closest relatives.

The gorilla and chimpanzee are the most like us. They are giant creatures, hairy and tailless, with long arms, big chests, and short stumpy legs. They look a bit alike, but you can easily tell them apart.

The chimpanzee is the smaller of the two. He's the one with the big ears—and a look of being very much surprised.

It probably comes from the curved ridges over his eyes which make him look as though he'd just raised his eyebrows.

The chimpanzee is the most familiar of our great ape cousins. You've probably seen chimpanzees at the zoo, having a wonderful time drinking out of a cup, examining the contents of someone's pocket, or eating tidily with a spoon.

The chimpanzee actors you've seen in the movies or on television have all been child prodigies—babies or quite young children. The young chimpanzee is a natural show-off. He is gay and affectionate and full of interest in his companions, human or chimpanzee. As they grow up, chimpanzees grow more sober and responsible. They prefer going about their own business rather than following their human friends about theirs. They are likely to resent bibs tied about their necks just as you would, and to get bored with roller

skating—though possibly not with riding about in motor-cars, which all chimpanzees who've ever tried it dearly love.

But even grown-up chimpanzees are still actors, fond of tricks and of doing things in very human ways.

In one zoo there is a monkey called Jimmy. If no keeper is in sight, he begs for peanuts and other tidbits from the onlookers. But as soon as his keeper comes in sight, he busies himself in tidying up, collecting bits of paper and shell from the floor of his cage. Then he skillfully catches the half dozen oranges tossed him for his supper, stowing them all away in his hands and feet and his capacious lower lip before he settles down to peel and eat them. When the keeper passes, he asks, "How was your supper? Good?" And Jimmy wisely nods, "Yes," and smacks his lips!

Chimpanzees, like people, are very different from each other in character and personality. Jimmy is a rather friendly creature, though he is a bit of a show-off. Clearly, he likes people, and is eager to be in his keeper's good graces.

Right across the aisle from Jimmy there is another chimpanzee with a different personality. He is a sulky, moody creature. But he is just as eager to be in the limelight, and is willing to play the clown to get an audience. He will lie quietly stretched out on a perch in his cage until a number of people have collected around Jimmy's cage across the way. Then suddenly he sets up a wild hullabaloo, screaming and swinging wildly about his cage. He goes so fast you can't make out what he's using for supports. It doesn't take long for his weird shouts and loud racket to collect a crowd, and just while they are most entranced by the great trapeze act go-

ing on—squirt! With deadly accuracy and perfect timing, a huge mouthful of water is sprayed out over the watchers. As the audience scatters with screams of laughter, he settles down to wait for them to disperse, looking as innocent and sluggish as you please—until he can collect a whole new batch of victims for his surprise practical joke.

Chimpanzees in zoos often have such tricks. They love to amuse themselves at our expense. Apparently they think *we* come to the zoo to amuse *them*. And when they throw pebbles and discarded orange peels or spit at us, as so many of them delight in doing, perhaps they are expressing the same resentment at recognizing a family resemblance that some of the onlookers feel on our side of the bars.

Gorillas are bigger than chimpanzees. Bigger than we are, too. A gorilla is quite easy to tell from his chimpanzee cousin. He has a huge round head, flat ears like ours, a strange pudgy triangle of a nose, and no neck to speak of.

A full-grown gorilla is a regular giant who may weigh several hundred pounds. If his legs were as long as ours, he'd stand taller than a rugger player—and be far bulkier. Sitting down—or rather sitting up—he looks most manlike; the first time you see a gorilla walk it is quite a shock, for he goes down on all fours, and his hindquarters and hind legs are so small in comparison with his giant front or upper half that he looks quite deformed. Instead of looking like a normal four-footed animal, he looks more like a crippled man. And yet that four-footed position is his normal way of getting about on the ground. Because he's grown so big and heavy, he uses the ground a good deal, although the forest is still his home, with the trees his retreat in case of danger.

Even today most people think of the gorilla as a huge, fierce monster. He is the nightmare villain of tales of horror from Edgar Allan Poe to the modern film. True, when he gets up on his hind limbs and stretches his mighty arms—with their reach almost twelve feet across—or beats them on his hairy barrel chest, baring his fanglike teeth, he is no relative to meet comfortably on a dark night.

However, you are certainly not likely to meet him, even in his homeland. The gorilla is a shy creature, and those who know him best say he's basically gentle, not aggressive. He's so shy it's hard to get a glimpse of him even when you look for him. Following trails crushed through the jungle by elephants, a gorilla band stays well hidden among the trees. There are lookouts to warn the group of any danger. You have to camp among them at night and watch them get up in the morning to count on seeing them at all.

No one has ever been close friends with a grown-up gorilla, but young ones are very bright, and very endearing. There was a young gorilla called John Daniel who grew up in a private home in London. He had his own bed and his place set at the table like anyone else. At teatime he would sit in the drawing room with the guests, drink tea from a cup without spilling it, and help himself to cakes when they were passed. When he wanted to go to the bathroom, he would walk upstairs, shut the door, and turn on the light—he never liked to be in a dark room.

As a tiny youngster John Daniel was very charming, affectionate, and well mannered, but as he grew older, he became a little boisterous—like any growing boy, but this growing boy was growing into a good-sized gorilla. He learned to use

tools—although mostly to take things to pieces—like many a human child. But he was much stronger than a child, and so much more destructive. Somehow guests did not like his leaping at them, even though it was all in fun. The family were finally forced to part with him. They missed him mightily. And he in his turn missed them so much that he pined away and died, chiefly of loneliness.



Our ape cousins from Indonesia are far less like us than the African branch of the family. The gibbon is such a small, furry fellow that when you first see him in the zoo, you may take him to be just a tailless monkey. Certainly his graceful, tiny body, with its enormously long arms and legs, doesn't look much like ours. But he has a charming wide-eyed face, with a delicate beard and an impish expression. The gibbon is really a tree dweller, swinging from branch to branch by his long arms with the most graceful movement imaginable, flying over vast distances from one tree to another like a highly skilled aerial trapeze artist—which is just what he is, though I have never known a circus to bill him as a performer. He moves through the trees like a grey ghost, so swift that the eye can barely follow him. When he does come to the ground, he runs along on his hind legs with his arms stretched out to help him keep his balance like a slack-rope walker with an umbrella.

The gibbon's red-haired neighbour the orangutan lives in the jungles of Borneo and Sumatra. He's a great lumbering fellow, very husky, but not as tall as a man. His legs are extremely short and stumpy. It's almost as hard to see him move as it is the gibbon—for the opposite reason. He moves so slowly it's hard to catch him going from one place to another. He likes to spend long hours at a time just hanging upside down from the branch of a tree. On the ground he scrambles along with his arms bearing the main brunt of his weight and his legs bent under him. A grown male orangutan is rather a strange-looking fellow, for he has a wide stiff circle of skin around his face—a sort of built-on ruff. Perhaps it is

connected with his extremely loud voice, but no one really knows.

For all his odd appearance, the orangutan's behaviour sets him, too, well up in the almost human class. Mrs. Belle Benchley, the woman director of the wonderful zoo at San Diego, tells amazing anecdotes of a young lady orangutan called Maggie who lived there. She was really just a child herself, but she had a baby brother to whom she was very devoted and of whom she took very good care. In fact, she "spoilt" him terribly. Maggie was a very fussy housekeeper, and made up a bed for herself and one for her brother every night—carefully spreading and respreading empty sacks until they were perfectly smooth. She could open locks and pick knots apart. She also got her own water from a regular faucet. However, she took to wasting so much water that the keeper removed the faucet from the water-supply pipe. That didn't stump Maggie. In no time at all, she had learned to turn the screw itself by inserting her strong, slender fingers—a natural "monkey wrench"!



Orangutan mother and baby.

Of course, it's a pretty far cry in some ways from these various ape cousins of ours—these great lumbering creatures with powerful arms and hairy chests, who carry their enormous heads thrust forward, who have no necks to speak of, and who cannot even walk erect comfortably—to us. But the resemblance, even superficially, is pretty striking. In fact, it is so strong that when these animals first became known in Europe, people didn't believe they could be *animals*. They thought creatures that were so much like us must be men—perhaps wild men who had lived in the forests without any kind of human civilization, and so had degenerated into a kind of bestial state. People who live in the various parts of the world where the great apes come from share a similar view. The very name *orangutan* means “wild man of the woods;” which is what his human neighbours in Borneo call him.

The likeness between man and the apes isn't just a surface one: it's a very detailed similarity. Darwin pointed out nearly a hundred years ago that “a medical student could work upon a gorilla, and trace almost every familiar nerve and muscle and blood-vessel connection, allowing only for slight differences in proportion.” He would even find that annoying little part of the intestines that sometimes gives us so much trouble—the appendix. You wouldn't expect your cat to catch your cold or your chicken pox, but if you had a chimpanzee pet, he might very well catch it. And then perhaps you could teach him to use kleenex for his sniffles! Apes can catch bugs from humans, too. That may not sound very significant, but actually, body bugs, surprising as it may seem, are *very* particular. They will infest only a *familiar* host, not some other kind of

animal. (That's not true of fleas, however, as some of you may know to your sorrow.)

Back in Darwin's day, his good friend Thomas Huxley wrote a book that was very influential in popularizing Darwin's ideas about evolution. It's a book you might still enjoy reading today. It's called *Man's Place in Nature*. And in that book, Huxley lists the many resemblances between man and his ape cousins which were known then, and points out how much greater the differences are between the apes and monkeys. Today we can carry the list much further. The apes are even known to have the same kinds of blood groups that we do.

Based on these resemblances, most biologists show both man and the apes developing from the same main branch of man's family tree.

It would be nice if all the details of this picture could be settled and agreed upon, but as yet they are not. Certainly, definite answers are much more comfortable than "maybe" or "it seems probable that..." But every science is full of questions, not just answers. Perhaps ours at this stage has just a few more than an average share.

Here is an example of the kind of question that isn't fully answered by a simple comparison of man and his primate kinsmen: Just exactly what is the relationship between the anthropoid branch of our family tree and the various monkeys? Are there really monkeys in our ancestry?

Of course, one branch of the monkey family is ruled out right away, by everyone's consent. That's the American branch of the monkeys. Apart from their tails, the American monkeys have some special traits that mark them off very

sharply. The differences are very technical. For example, they have one extra bicuspid tooth in each half jaw, and their noses are very flat. (Their technical name *platyrrhine* means "flat nose" in Greek.)

Of course, all monkeys have flat noses compared to people, if you look at them in profile—all except one odd fellow who looks a little like Jimmy Durante. Apart from his, monkeys' noses don't stick out. But American monkeys have wide nose bones so that the nostrils are wide apart, whereas other monkeys are "narrow noses" (*catarrhine*) with their nostrils close together—and so are we.

These differences may sound rather dull, and perhaps trivial, but actually they are important because they give the biologist a direct message. They tell him, "The American monkeys had a different great-great-grandfather some place along the line. They are a separate branch of the family that's been cut off to develop in its own peculiar way in a separate land."

But what about the Old World monkeys? Did they once scamper about on our family tree?

They have narrow noses, like us, and they have the same arrangement of bicuspid and molars. Most scientists say we just have to accept them as kinsmen. But a few say no. They



say the monkeys are so four-legged that we should bypass them in drawing our family tree. They point out that lemurs and tarsiers are far more upright. This "minority report" would trace man's ancestry directly back to a lemur or tarsier, and leave other primates out on a limb.

What does the fossil record have to say about such questions?

What does it have to say about the whole picture of man's family tree?

Actually, the fossil record isn't detailed enough to settle all the disagreements, but it is full enough to give considerable support to a "majority opinion" on most questions.

When we look at the fossil record, we find that man's family is as ancient as that of any of the other mammals. Way back sixty million and more years ago, when the ancestors of the horses and the cats and all the other mammal families were beginning to take their separate paths, our ancestors too can be found, already beginning to be primates.

These earliest primates were very much like the lemurs of today. There were quite a lot of them way back then. A few survived; many became extinct. And others were destined to change, to turn off the lemur track to become far different, more advanced, primate forms.

There were quite a number of early tarsiers, too. They were not nearly so odd as their modern descendants, though. They had not developed those built-in finger gadgets! These tarsiers, too, may belong among our ancestors. They represent a stage in primate development a little farther along than the lemurs.

The first fossil monkey appears in the record about forty million years ago. This was a period the geologist calls the *Oligocene*—the time when there were “just a few” modern forms, like a giant shovel-headed ancestral rhinoceros, and a tiny tuskless elephant no bigger than a pig.

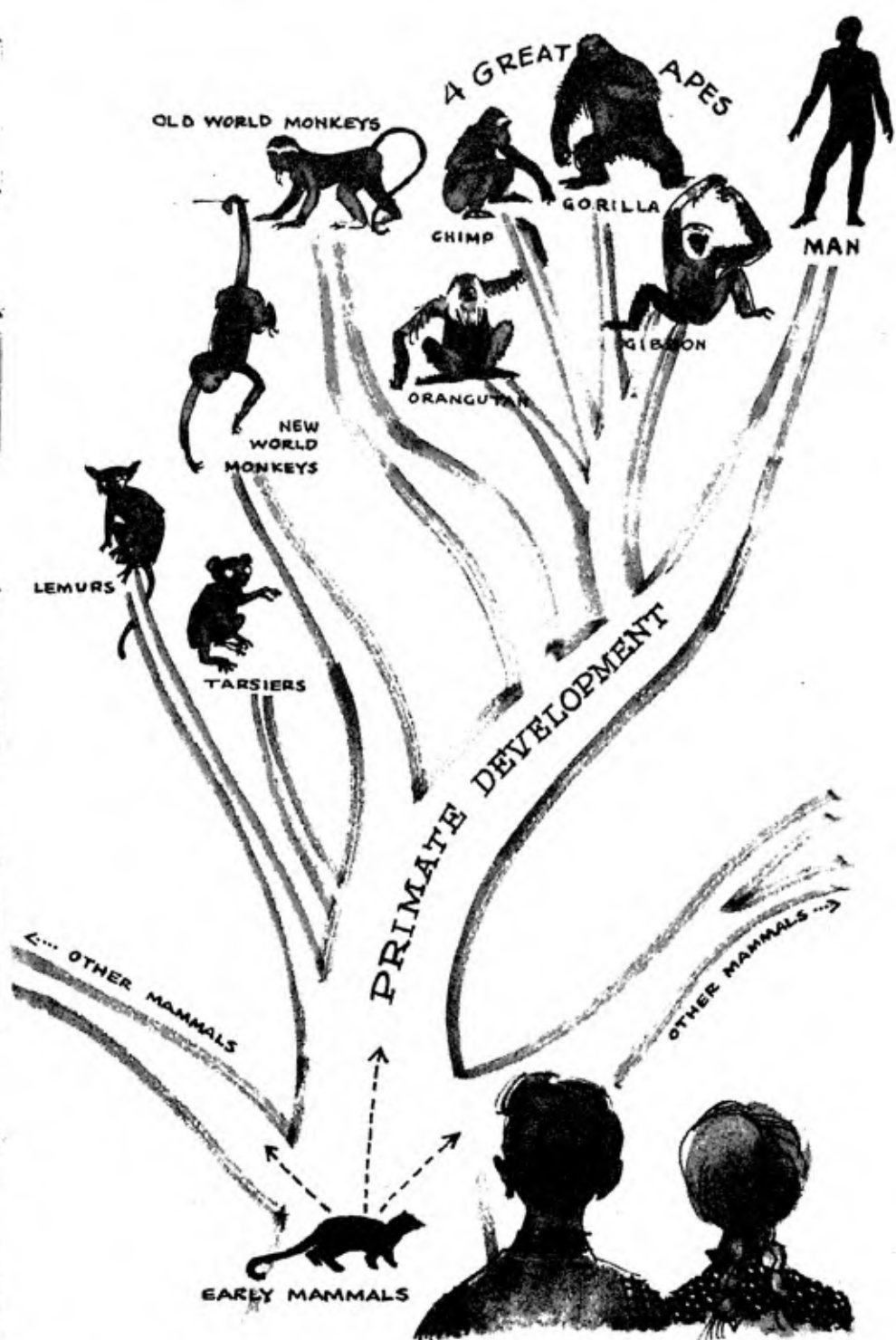
This oldest fossil monkey was a graceful little fellow who lived in the Fayum in Egypt. Nowadays, that is a desert country, but once upon a time it was a rich tropical forest. The little *Propithecus* who lived there so long ago was very much like the monkeys of the modern world. We can easily imagine him running about in the treetops as they do, and chattering away.

Was *Propithecus* one of our great-great-grandfathers?

Well, unfortunately, the little skeleton from the Fayum doesn't have a printed identification tag on it! He's the oldest monkey skeleton that's been found, but the world may have been full of monkeys by that time. There's good reason to think the American branch was already cut off, way back then. That means monkeys were already quite old in the world. So it may well have been some other *Oligocene* monkey, one we haven't found yet, who was destined to give rise to us!

Or, more likely, by that time the anthropoid branch of the family—including us—had already begun to take its separate course. This is especially likely because the very first ape skeleton turns up in the record not long after that first monkey. This first ape we know about was a gibbon, who also left his remains in the Fayum desert.

But that doesn't mean that the gibbon was the first ape, or that he was our own direct ancestor. He's just one indi-



vidual whose bones happened to survive. He may still be a separate little branch of the family tree, not very related to the rest of us at all. For the gibbons are in many ways rather different from the rest of us apes!

For the rest of us the record is silent until *Miocene* times—the next great time division. That's about ten or twenty million years ago. There were lots of apes by that time, and some of their fossil remains may be fragments of our own direct ancestors. At least, that's what their teeth suggest. Unfortunately, their teeth are all we have. But Dr. William Gregory has spent so much time and trouble on just teeth that they can tell him quite a story. And he says that a Miocene ape called *Dryopithecus* had bumps and ridges on his teeth that were on their way to becoming exactly like ours.

Each of these fossils—from the first lemur to the possible first ape-about-to-turn-into-a-man—marks a definite step forward in our primate inheritance. Each of them established new primate patents that were to be part of our heritage—the models for our sharp eyes and nimble fingers and clever giant brains.

Let's see now how these steps forward were taken—how our primate ancestors long ago laid the groundwork that made our emergence possible.

7.

NEW TOOLS FOR LIVING

*M*AN himself is a newcomer in the world. But his family is as old as any of the other mammals.

Sixty million years ago the ancestors of all the different kinds of mammals were developing the bodies and skills to go with various different life ways. That was when the ancestors of the horses and cows learned to eat grass, and to run swiftly over the plains on their tiptoes. And that was when the ancestors of the cats and dogs were growing their splendid hunting equipment of tooth and claw and quiet padded paw.

It was then that our ancestors, too, chose their way of life—a strange way of life—in the treetops.

Life in the treetops provides a rich and varied diet. There are leaves and bark, fruits and nuts, insects, small birds and their eggs. But most of this food needs some preparation—fruits have to be peeled, nuts shelled. And the treetop perch has its own dangers. To sit and peel a fruit while watching out for enemies from the sky and still maintain your balance on a small swaying tree branch, or to carry food—and sometimes babies—to a quiet safe spot—these things de-

mand a high level of acrobatic skill, and very sharp eyes and quick wits.

This choice of a way of life was a fortunate one for us. It led to grasping hands and feet—for gripping branches and handling food. It led to eyes that could see a piece of fruit in the next tree or gauge the distance for a leap from bough to bough. The challenge of a home in the treetops also led to the most important primate feature of all—expanded brains, to take care of the new kinds of clues coming from sight and touch, and to coordinate the highly skillful movements of the fingers, hands, and acrobatic bodies.

*In the early days of the mammals
our lemur ancestors found safety
in the trees.*



These main features all began to be worked out way back when our ancestors began and were slowly improved upon until, finally, man could develop—a brand-new model based on all these earlier steps forward.

Hands were probably the first primate characteristic to be worked out efficiently. Not all primates are exactly alike in any trait: there is always some difference between the animals in any large family, just as there is between brothers and sisters and cousins in a small one. But all the primates have hands. Not hoofs or paws, but actual hands, with separate moving fingers, and usually a thumb that is “opposable”—that is, that can be placed opposite the other fingers for a better grip.

Did you ever watch a squirrel climb a tree? He sticks his claws into the bark like a telephone linesman climbing with spikes. So does a cat. Not the monkey, though. He runs up a sloping trunk on all fours, or he leaps from the ground and catches a bough, or he swings to the treetops by grasping a trailing vine; and when he must climb directly, he uses his hands and feet to encircle the trunk or limb. The hand goes right around the bough, and the thumb comes around on the opposite side.

Most monkeys have such grasping hands not only on their arms, but on their legs as well. If you have ever watched monkeys, you know that they can pick things up and hold onto them with their feet. They are really four-handed creatures, rather than four-footed. In fact, zoologists have given them a technical name, *Quadrumana*, which means four-handed. Of course, these hands aren't as good for walking



on the ground as feet are, but the monkey doesn't spend very much time on the ground. His firm grasping hands make it possible for him to run nimbly and safely along the branches on all fours. And the lemurs and tarsiers use their hands for grasping, too, though the lemur's hand is not quite so flexible.

The monkey's flexible hand is not only good for his kind of locomotion, it's also good for *handling* things. And that is particularly important in the trees, too. If you have ever fed a peanut to a squirrel, you've seen that he too eats by picking up his food in his paws, holding it while he nibbles at it. Tree dwellers really have to be able to do something like that. You can't rest something on a branch while you poke at it cat fashion with your mouth; more of it would fall to the ground than you would ever get a chance at. But the squirrel's hands aren't nearly so efficient as the mon-

key's for handling food. The squirrel has little fixed paws, not especially well suited to this task. Tree dwelling isn't such an ancient part of his heritage as it is of the primate's; his family line, the rodents, more often live in holes and burrows in the ground. His paws probably got their start long before he moved into the trees. A monkey's hands are far more suited for handling: the fingers are separate and flexible, and they have very sensitive nonskid finger tips that make fingerprints in circles and ridges just like yours. And there aren't any claws to get in the way: monkeys and other primates have fingernails like yours and mine.

Hands like these, found among the simplest primates today as well as among the apes and ourselves, go back to the very beginning of primates, in the early forests of those days sixty million years ago, when they and other mammals began. There have been some changes since those days. The tarsiers have gone off in a queer direction of their own, perfecting their most specialized built-in gadgets. We have given up the handedness of our hind limbs, dedicating them instead to carrying us about. In return for the loss of flexibility in our feet, our two hands have gained far more freedom, and the chance to develop special skills. Some of our primate fellows, on the other hand, who use their hands a great deal for swinging, have lost part of the separate use of their thumbs. Very likely the thumb sticking off at an angle proved a nuisance and liability in reaching out through the air to grasp another trapeze; animals born with shorter thumbs were less liable to injury. But all the apes and monkeys have hands, and use them, and with their help have gone on to develop better eyes and brains than any other creatures.

The primate eye with its new position in *front* of the head was the next great patent to be worked out by our ancestors. The special quality of the primate eye is the ability to focus sharply on one thing with both eyes at the same time. Most animals have their eyes set on opposite sides of a snout; in some cases they don't even face directly forward; in any case, each eye has a somewhat separate field of vision. The primate eye, set forward in the head, can see things sharply at closer range. Other animals must move their heads to move their eyes. We and the apes can move our eyes, and pictures from both eyes are sent together to the brain.

All this extra seeing goes along with picking things up and handling them; it has no special place in the life economy of an animal that has to smell and sniff along the ground. Primates have come to depend on seeing rather than smelling; for them, living up in the trees, smell isn't nearly as useful as for those animals that live on the ground. We haven't lost our sense of smell. Even man has 1900 complex nerve centers in each nostril. But we and our primate cousins no longer depend on smell for our major cues to food and safety. With this loss of dependence on smell primate snouts, too, have grown smaller. We can all bring things up close to our eyes for inspection and turn them about in different ways with our hands. We don't have to keep our mouths at nose length in order to see what we are eating!

Being able to focus with both eyes makes depth perception far more accurate. For a creature who has to swing from one branch to another high up in the treetops life and safety may depend on being able to judge distance well. To this necessary good our ancestors added another advantage in seeing

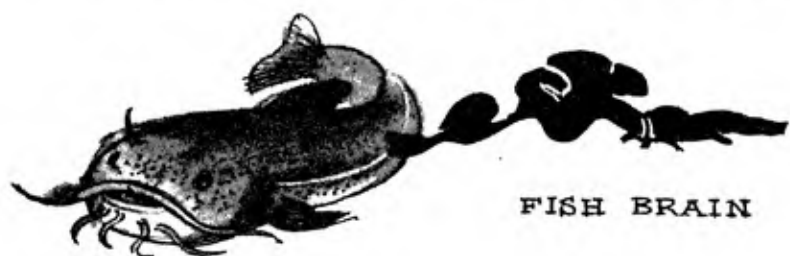
which you have probably been taking very much for granted. The brightly-coloured world that we see does not appear that way at all to most mammals. Birds and insects have colour vision, but not dogs and cats and rats. They cannot tell colours apart, as we and our primate kinsmen can. The physiologist knows this from a study of the structure of the eye. The psychologist confirms it by seeing that laboratory mice can learn to tell black and white doors apart, but not red and green ones. A chimpanzee, on the other hand, can do quite a neat job of colour matching.

These improvements in vision didn't come about all at once. The lemurs even today have their eyes moved forward only a little. The tarsiers took part of this forward step; their huge eyes are set neatly in front of their heads, but they don't move and focus sharply. Thus primate eye development seems to have come about a little later than the hands, and to have depended on the use of the hands for its beginnings. But it was clearly established by the time the first monkeys appear in the fossil record—about forty million years ago.

Perhaps the most significant primate specialty of all is the great growth of the brain, to meet the needs of all the important new senses and new skills. Of course, brains weren't a new invention made by the primates. Brains began way back when very simple animals developed ways of sending messages from the outside world to different parts of their bodies. The jellyfish has a whole ring of sensitive co-ordinating spots around the edge of its umbrellalike body; each is a kind of small telephone exchange, sending out messages and receiving them within its own station area. Each tells its own par-

ticular tentacle to pull in if it touches something sharp, and so on. But the sensitive spots are ringed together, so that some small interchange of communications between the different exchanges also takes place.

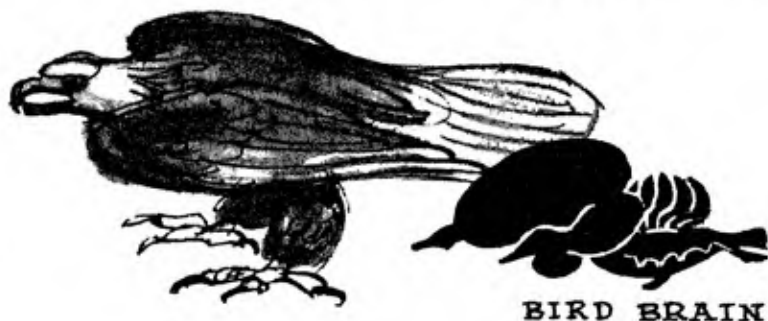
Brains grew more formal as animal life progressed: all the mammals have pretty good-sized brains compared to earlier animal forms. The giant dinosaurs, for example, were pin-heads compared with the mammals of today. The brains in their huge bodies of several tons were smaller than a kitten's. That's quite a contrast to the giant mammals of today, like



FISH BRAIN



REPTILE BRAIN



BIRD BRAIN

the elephant and the whale, whose brains are very much larger than yours or mine, though much smaller in comparison with the whole size of their bodies.

It isn't just the whole brain that gets bigger and bigger, to reach a climax in man. The main growth is of a special part of the brain, a part that is first developed in mammals. A fish's brain is just a swelling at the head end of his nerve cord. A lot of the work that his nerves have to do is routed directly through the little branches that go into and come out of the long nerve cord that lies protected inside his spine. Signals



MAMMAL BRAIN



APE BRAIN



MODERN MAN BRAIN



come in about pressure, fin position, and so on, and they work automatically to change his position so that his balance is righted. It's an electronic arrangement like the automatic pilot in a plane. Even the messages that do go to his brain are very simple ones, and they are routed right back into the system of automatic controls.

Mammals—including us—still have plenty of jobs that have to be handled automatically, some in the nerve cord, and some in the old brain, quite like the fish's brain, which we still have. We would be in a pretty tough spot if we had to think about everything we do. Think how complicated life would be if we had to consult our memory files about what a particular pressure signal meant, so that we could stand more erect, or decide when to start lifting the left heel and how far, and when to lower the right in order to take a step forward, or if we had to decide for how long to turn on the sweat glands in order to cool off.

But in addition to these automatic and "reflex" functions we do have whole complicated new tasks in which our brains have to be involved. There are messages from sight and touch and smell that have to be handled at a central switchboard; there are giant memory files and control centres which have to set courses of action going. In somewhat simpler form, all the mammals also "live by their wits," at least in part. To handle all this, mammals have a new kind of brain part that grows up like a mushroom right over the old brain. This new part, the cerebrum, is made of heavy, white, fibrous stuff, through which the lines run that bring in and take out the messages, and it has a coating of thick, spongy, greyish stuff, called the cortex, or bark. This cortex is the real headquarters

of the "higher" mental processes, co-ordinating messages, consulting the memory files, sending out warnings and directions to the whole body, doing our thinking.

Whether or not our mammal friends like the horse or cat "think" in our sense of the term, they are certainly capable of a good deal of intelligent behaviour, learning new things and changing their behaviour when necessary to meet special circumstances. A dog learns to live in a house, not to soil it or chew the furniture; he can learn to retrieve hunted game instead of eating it. A rat will learn to take the right turnings in a maze if that wicked conspirator, the animal psychologist, has arranged things so that only in that way will it come to the rat dining room. Of course, it may take quite a long time to learn, but, within limits, it gets there. All the mammals, though they cannot learn to talk or do arithmetic, are teachable to some extent, in ways we would not expect of a fish or a frog.

The primates are more intelligent, in a human way, than any of the other mammals. In all the primates the gray matter has grown so large that it covers over the whole old brain.

Even the tarsier's brain is larger than that of most other mammals. And it's more geared to sight rather than smell. The tarsier already has the first beginnings of our built-in "thinking cap." As for monkeys, they're very smart creatures, with a brain outline that's already much like ours. But the surface is smoother. In man and the apes, the grey matter that covers the cerebrum is much, much bigger than it looks: instead of being just a cover stretched smoothly over the white mass, it's all pleated and folded. This allows for a great deal more of it than shows on the surface. Just think of an accor-

dion pushed together and the amount of surface there actually is when you pull it open, or the tiny compass into which a magician can fold a large silk handkerchief by pleating it, and you'll see what a vast amount of surface can be packed into a small size by folding.

Man's cerebral cortex, the grey matter that we have been talking about, is thickly folded in upon itself. It forms a regular pattern of looped sections and whirls that's quite definite and just about the same for all people. And the ape's brain follows the same general pattern and arrangement as ours, though some of the sections are smaller.

The ape's behaviour shows the kind of high intelligence that is indicated by the shape and size of his brain. There is lots of evidence for this—some in anecdotes, and some in formal tests by scientists.

Most elaborate studies have been made of chimpanzees. One German psychologist, Professor Wolfgang Koehler, lived with a colony of chimpanzees for many months. He found that they were able to use tools. They would push a stick through the bars of their cage to rake in a banana, or carry a box over to set down under a hanging banana in order to reach it. Mind you, these weren't things they were taught to do by Professor Koehler. They tried hard enough to get him to help them; that was always the first thing they did try when he set them a hard problem. They would walk over to him and poke at his trousers, look up and make little pleading sounds with their lips thrust out, quite pitiable. But of course he couldn't help them. The whole point was to see how far they would get by themselves.

Sometimes they made very funny mistakes, like using long

straws instead of sticks, as if they didn't quite understand that the stick had to be firm as well as long in order to do the job. And instead of reaching up with a stick to pull a banana down, which would seem to us the easy way to do it, they would often rush right up the stick and then jump from the top, sailing out into the air like a pole vaulter. This technique proved so much fun that they started to play it as a game. It became quite a rage at the colony for a while.

One of Professor Koehler's apes was obviously much brighter than the rest. He was a youngster named Sultan, and Professor Koehler was much impressed with the way he solved problems. Sultan didn't just go at things hit or miss. He seemed really to think them out. Once there were several sticks lying about, all of them too short to reach the bananas. Sultan looked about, poked a little at the fruit with the too short sticks, and then went away, seemingly no longer interested. He started playing about with the sticks themselves, sitting down and peering at them, touching them with his lips, knocking them together, just as a young child does when it is learning to handle objects. The sticks were pieces of bamboo. That means that they were hollow, and Sultan also liked to peer through them. At one point in his play he inserted the end of one into the hollow of the other. Suddenly, as Professor Koehler describes it, a light seemed to dawn on him; thrusting the sticks more firmly together, he got up, walked deliberately over to the side of the cage where the bananas lay, and with his new, longer stick he pulled them in. Professor Koehler has called this the "AHA" phenomenon—solving a problem by thinking it through, until you suddenly "see how."

Meanwhile, in addition to showing that he could carry out an act that really required remembering and thinking, Sultan had also done something else. He had shown that an ape could not only use simple tools—he could even make one. And know what he was doing. Because after that Sultan had no trouble repeating this little stunt deliberately; whenever he wanted a longer stick, he would put two sticks together; and he learned to pile boxes on top of each other to reach a high place, too.



Chimpanzees do well on many kinds of intelligence tests.

Psychologists have spent a great deal of time and ingenuity on devising ways of exploring ape behavior. Some psychologists at Columbia designed a machine which they called a "chimpomat." It would deliver raisins when the chimpanzees put in a token coin. There were two colors of tokens, and one delivered several raisins, while the other only doled them out one at a time. He found that the chimpanzees could easily learn to work this machine, and that they were willing to work for the tokens as readily as for food. What's more, they would work harder for the more valuable ones. And when the door between their cage and the room where the machine was kept was shut, they would save up their tokens to use when the door was opened. They would even borrow or lend them, begging through the bars of neighbouring cages. Sometimes one of them would grant a companion the favor of a token or two, just as he might grant a bite or two of food if he felt generous—or not very hungry.

It isn't always an easy job to design tests for animals, even for clever animals like the apes. After all, you can't tell them what you want them to do, so it has to be absolutely clear in itself. Some psychologists worked out a most ingenious puzzle box. It was built of wood; one long box was fitted inside another, so that it could be pushed in or pulled farther out. The box was tried out on some young gorillas. They watched the experimenter drop in a piece of food and then lock up the box. There was a slot in the top. By pushing the lower box directly under the slot, the gorilla could reach in and get the food out. The mechanism wasn't too difficult for them. They pushed it around a little, and soon got the point. From then on they could always get the food out in just a few seconds.

Then someone thought this would be a fine way to test the comparative intelligence of gorillas and other apes. The same mechanism was therefore set up for Maggie, our orangutan friend from the San Diego zoo. Maggie watched with great interest while the experimenter dropped in the food and locked up the box. Then—she picked up the whole works and calmly took it to pieces! This may have been hard on the experimenter and an extravagant use of boxes—but from the orangutan point of view it was certainly a speedy and intelligent way of solving the problem, which could only be seen as “Get at the food, but quick!”

There’s no question about it. These ape cousins of ours are extremely clever. Their large brains go along with the ability to cope quite efficiently with new situations. And that really is intelligence.

But there is one important difference between ape intelligence and ours.

The great apes can’t talk.

Many attempts have been made to teach them. Some, that have lived with humans, have actually learned to understand a number of spoken words—but they couldn’t learn to say them—nor even to understand them in the way that we do.

Mrs. Cathy Hayes, who lived in a primate research colony, took a baby chimpanzee to live with her. Vicki lived in Mrs. Hayes’s home as a member of the family till she died at the age of six. She could do many human things, but she never learned to talk. By opening and shutting the ape’s lips with her hands, and a great deal of patient repetition, Mrs. Hayes finally succeeded in teaching Vicki to say, “Ma.” But she

didn't really use it as a name. It was just a way of calling for help of any kind.

Gibbons do a great deal of "talking" and calling. They make at least fourteen different sounds, which certainly act as signals. But this isn't language in the human sense. The various sounds just express different moods—like fright and anger, and joy.

The growth of our hands we owe to the first of our primate ancestors, who took to life in the treetops. The beginning of our sharper eyes and larger brains also goes back quite a long way, to the needs of those early days. And the ape stage in our ancestry meant a really big step forward in brain size, brain design, and brain power, but of course it didn't come all the way.

Our ape heritage also contributed a great deal to the overall plan of our bodies. The monkeys were treetop dwellers who ran about on all four legs. The apes had an altogether different way of life. Our great ape cousins of today—and the great apes who were our ancestors long, long ago—are tree dwellers, but they don't run about among the treetops. For one thing, they're too heavy! Their lives are lived among the heavier lower limbs, and even, in part, on the ground. And this way of life had its effect on the bodies of our long-ago ancestors, and on us.

The apes of today do not spend a great deal of time on the ground. They retreat very quickly to the safety of trees—or, in the zoo, to a trapeze or jungle gym. All the apes, except the fathers in gorilla families, spend their nights in nests they weave in the crotches of trees, where the lower limbs branch

off. Each builds a new nest every night, sitting in one place and weaving the boughs in under him, then filling in with broken-off twigs and leaves. He or she is right in the middle of the tree-house bed when it's finished—and goes off to sleep for the night. Mama takes her smallest youngsters in with her; older ones can shift for themselves. And Papa—if he's a gorilla—settles for a quiet berth at the foot of the tree where he can guard his family even as he sleeps. These nests have to be abandoned as they grow soiled, or the group moves on to seek fresh fodder. It takes quite a lot of vegetable food to satisfy a family of apes—especially gorillas, who



eat mostly bulky foods like bamboo shoots rather than more concentrated foods like fruits and nuts.

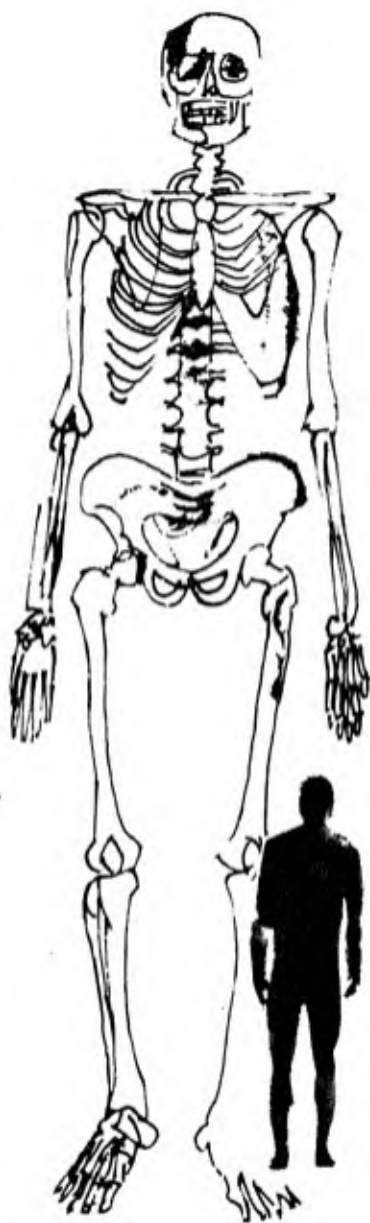
When our ape cousins are up in the trees they have a way of moving about in them that is quite unusual—so unusual it even has a name of its own. It's *brachiation*. Brachium means arm, in Latin—and the word means getting about by means of the arms—which is just what they do. They move along among the heavier, lower tree limbs by grasping a branch with one powerful hand, swinging like a giant pendulum, and so reaching out to catch the next limb with the other hand.

And that is how our own ancestors must once upon a time have lived and moved. Our bodies bear witness to it in many ways. Our early ancestors need not have been so thoroughly adapted to this way of life as the apes of today. After all, our ape cousins have been at it for millions of years longer. They've become so used to it they're *bound* to it. Their arms have grown longer, and their legs much shorter. Probably they could no longer escape from the trees as completely as our own ancestors did long ago. But our ancestors had worked out some of these adjustments, and we are heir to them, for better or worse.

One important heritage from this ancient past that stands us in very good stead is the arrangement of our shoulders and arms.

Monkeys' arms are set close together. Their chests are narrow—almost pointy in front. Their arms have very little more freedom of movement than other four-footed creatures.

Man and the apes are not built quite that way. We have great wide chests, and our shoulder blades stretch out to the side, leaving our arms free to swing in almost any direction.



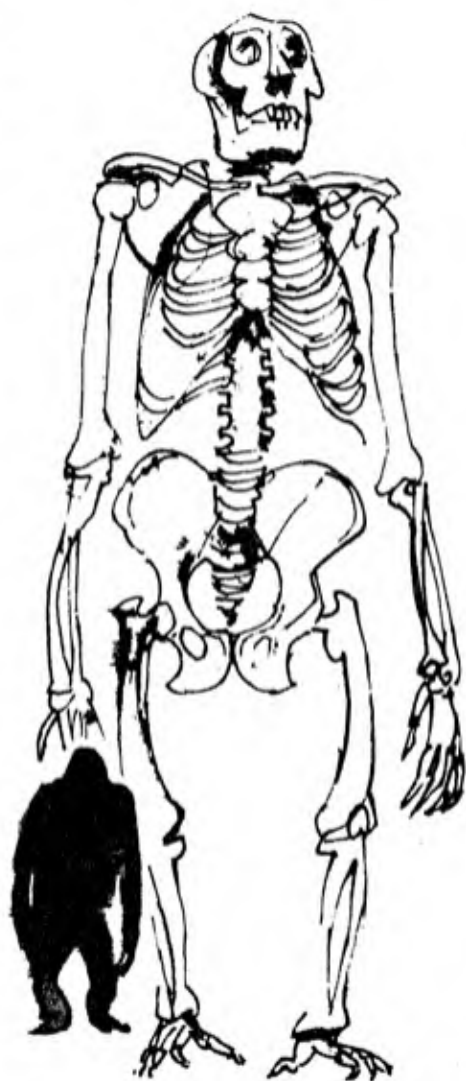
Human skeleton

This arrangement probably arose as a good adjustment for a heavy animal swinging by his arms. But it has meant a great deal to us in our very different world, for combined with the skill of our flexible fingers, it has made possible all the wonderful things we can do with our hands and arms.

Another thing the anthropoid branch of our family shares with us is our posture. Of course, we did say that the apes do not stand erect as we do. They do not walk about in an upright position, but they do sit up, and their backs are upright when they swing by their arms. They are usually called semi-upright, and their backs have almost the same kind of double-S curve that ours do. This is entirely different from the arched back of a typical four-legged creature. It's a sorry horse that sags in

the middle as we do!

The ape's head shares in this semi-uprightness. This is shown very neatly by the way it is attached to his spine. Our heads are nearly round, and neatly balanced on top of our necks. The opening for the nerve cord, which is also the balancing point where the neck and head are joined, is tucked way underneath our skulls. A four-legged creature, with his spine more or less parallel to the ground, has his head joined on differently. It is attached to his neck at a point which is not underneath the skull, but in the very back—at the opposite pole from the face, so to speak. If our skulls were set on our upright spines in that way our faces would be looking right up at the sky! (Try it out for yourself with a pencil for the spine and a ball for the head.) The ape's head is sort of in



Gorilla skeleton

between, like his posture. His head is attached at a point which is on the back of the skull, but way down near the bottom. It doesn't balance as well as ours, so that he needs strong muscles to hold it in place, but it is a step in the direction of uprightness, and this step is one that probably goes way back to our common ancestry.

So, in all probability, does the loss of the tail, which is another trait we share with our ape cousins. We are all tailless, at least on the outside. Actually we do have tiny tail bones, four or five of them, tucked in at the end of our spines. And the muscles that once moved our tails have been set to a new use: they help to straighten the bottom of our body cavity, and so to hold our heavy insides in place. This is a necessary kind of support for a creature that has reared up on its hind legs. It is a useful part of the primate heritage upon which our special humanness was built.

8.

WE TAKE A BIG STEP FORWARD

UP to this point, we've come along with our primate relatives, especially the great apes. Together, long, long ago, our primate ancestors grew to be powerful animals, cleverer than other beasts of the field or the birds that fly in the air. They had clever flexible fingers, and eyes that could focus together sharply even on a tiny thing. They were large animals, with mobile faces, and no tails. They held themselves somewhat upright, and their eyes were set well forward on heads set high between their broad shoulders.

But now we come to a parting of the ways for apes and men.

Just what was it that happened, twenty or thirty million years ago, that set our ancestors off on a path of their own?

The really big happening as far as our history is concerned is that some time along about then one family among the apes left its home in the trees and took to a life on the ground.

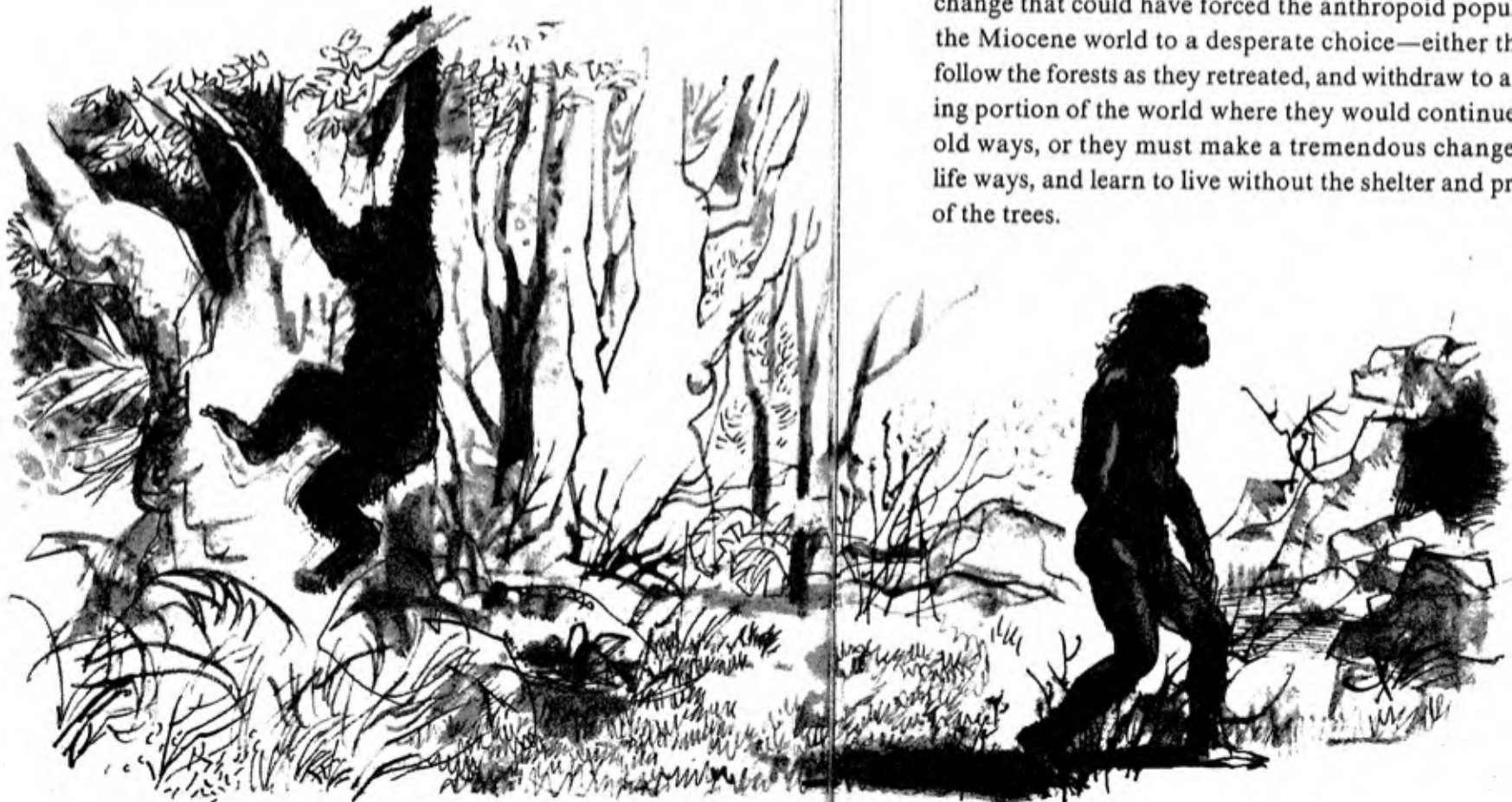
Coming down out of the trees is quite a drastic step. No animal makes such a change in his way of living without a pretty good reason. Even men don't change their life ways easily—and our habits aren't so built-in as those of other animals.

Probably it was some change in the condition of the world they lived in that caused our ancestors to take this important step.

The geologist can give us some idea of what this change may have been. In those times—the period the geologist calls the *Miocene*—the world was going through vast upheavals which were changing the whole structure of the earth's surface. And one of those changes was the birth of the Himalaya Mountains.

The birth of a mountain range does a lot more than change the scenery; it changes all the wind and water conditions in

its neighbourhood, and for great surrounding areas. Winds that bore their burden of moisture-laden clouds inland from the seas are now reflected back by the high mountain barriers. Whole masses of land are cut off from their source of rainfall, and inevitably, they dry up. The new mountain peaks act as a new watershed, too, and change the direction of streams and rivers. Areas once lush and tropical, cut off from the rains and rivers that supplied their water, slowly grow dry. Forests change to sparse woodlands, and finally to plains, and even to deserts. That is how the Gobi desert was formed in what was once a rich and fertile land. And that is the kind of change that could have forced the anthropoid population of the Miocene world to a desperate choice—either they must follow the forests as they retreated, and withdraw to a narrowing portion of the world where they would continue in their old ways, or they must make a tremendous change in their life ways, and learn to live without the shelter and protection of the trees.



Of course, this was not a conscious, deliberate choice. But these were the alternative ways by which they could survive.

The first of these was the path that the ancestors of today's gorillas and chimpanzees must have taken. Continuing their life among the trees, pushed into a narrowing area of possible homeland, they spent the next millions of years perfecting their adjustment to this limited environment. Their arms grew longer, their legs shorter, as they placed increased reliance on their "brachiating" heritage. Perhaps even the rather heavy jaws that characterize all our modern ape cousins date from these recent times. The gorilla may owe some of his heavy jaw—and the great skull ridges that go with it—to his diet of shredded bamboo bark.

But our own ancestors, it seems, were able to choose a different path, way back then, a path that led along the ground. Somehow, among the apes of those days, some were born with better balance than the rest. They were able to take longer distances on the ground in their stride, and to gain their safety by throwing sticks and stones instead of retreating to the shelter of the trees. Slowly these ground-dwelling apes perfected this new way of life, with its new possibilities and new challenges, and thus took the final steps that led to us.

"Taking this change in their stride" is not just a figure of speech. We can take it quite literally. For these ancestors of ours took to the ground *on their feet*, and so freed their hands for new tasks.

This was a most important development. After all, baboons too took to the open country. They live among rocky cliffs, on the ground and in caves, just as these early ground-

dwelling apelike ancestors of ours must have done. But the baboon, starting with a monkey heritage of running about among the branches on all four legs, remained four-legged when he became a ground dweller. Our ancestors were apes, not monkeys, when they came down from the trees. Their backs were already somewhat erect, their heads set high for convenient swinging from branches or legging up tree trunks. Probably they were already accustomed to occasional short dashes on the ground.

Perfecting this heritage for life on the ground meant learning to hold their bodies more fully erect. Small changes had to take place in the hips, and in the attachment of the leg muscles, if the legs were to stretch out in line with the spine, and do the full job of supporting and moving the body. Bone and muscle readjustments were needed in the foot, too. None of the apes has a really well-developed foot; it is still more or less of a hand, except perhaps in the gorilla. What has happened in our foot is that the big toe, instead of sticking out sideways, like a thumb, has moved forward to line up with the other toes. Its bones are part of the supporting arch at the ball of the foot, making the foot both well balanced and springy.



Perhaps some day a fossil footprint will tell us more of our ancestors' first tottering footsteps. Meanwhile, we are fortunate in having in the fossil record not the feet, but at least some of the leg bones of an early ancestor of ours who had made the transition to fully upright posture, though he was not yet quite a man.

These fossil missing links are none other than the ape-men or man-apes from South Africa whose remains Gert Terblanche stumbled upon not so long ago near the mine works at Sterkfontein.

Gert's fossil was not the first of these man-ape creatures to be discovered. The very first had turned up quietly some thirteen years before. Professor Raymond Dart, who taught anatomy at the University of the Witwatersrand, was hard at work in his office, one day in 1925, studying the skulls of some early types of baboons which had been unearthed in the neighbourhood, when a colleague knocked at his door. He wanted to show Dart a fossil skull that had been given him by the manager of a mine he was visiting as a geology consultant. The skull had turned up in some cave deposits high up in the cliffs where the miners were blasting out limestone, and fortunately someone had noticed it.

Dart looked at the pieces of bone with mounting excitement. This was no fossil baboon, no mere monkey skull: these were pieces of the skull of an early ape. Perhaps it would prove to be one of man's ancestors! Working carefully, Dart removed the fossil parts from the matrix of stone in which they were embedded. He found he had the cast of half a brain and most of the face of a young child, so young it still had its baby teeth. Although in some ways the creature did

look like a little chimpanzee, Dart thought that this was a very superficial view. Examined carefully, the skull seemed to him far more human than any ape he had ever seen.

Delighted at his discovery, Dart allowed a story about it to appear in the local South African newspapers. What could be more natural?

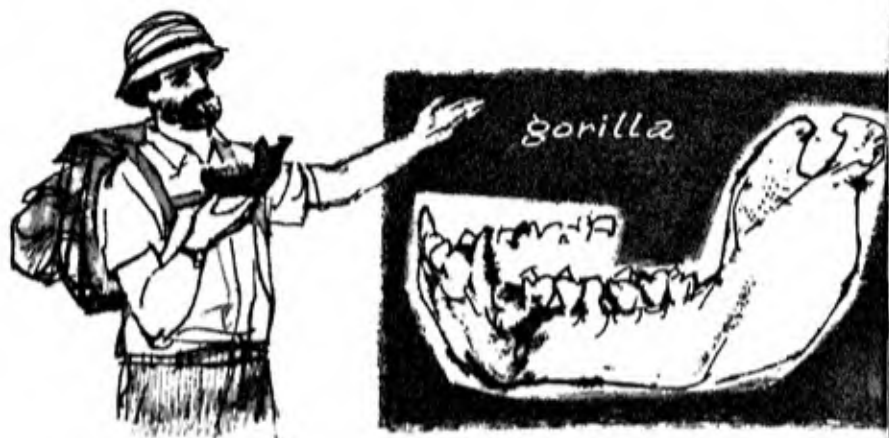
But everyone was shocked. This was breaking all the "protocol," the rules of diplomatic procedure in the fossil-man field. Fossils had lain unknown and unnoticed for months and years, and no one seemed to mind. But to let one come out into the world before other scientists had had time to examine it and give it their official blessing—unheard of!

Perhaps it is just as well that Dart announced it when he did, because otherwise he might have been discouraged from presenting it to the world at all, considering the reception it got. Scientists discussed and debated the new ape-man, or man-ape, and most of them only scoffed. "Just an odd variety of chimpanzee" was one very generally held opinion.

One of the chief difficulties about identifying this little creature and putting it into its proper place was the fact that it was so young. You remember that you lost your baby teeth by the time you were six or seven years old. So would a little chimpanzee. The fact that this little long-ago creature still had its baby teeth shows that it could not have been any older.

Now men and apes aren't nearly as different when they are children as they will be later on. A six-year-old chimpanzee and a six-year-old child are both rather smooth-faced creatures. The huge jaw and heavy bone ridges that will characterize the adult have not yet made their appearance in the

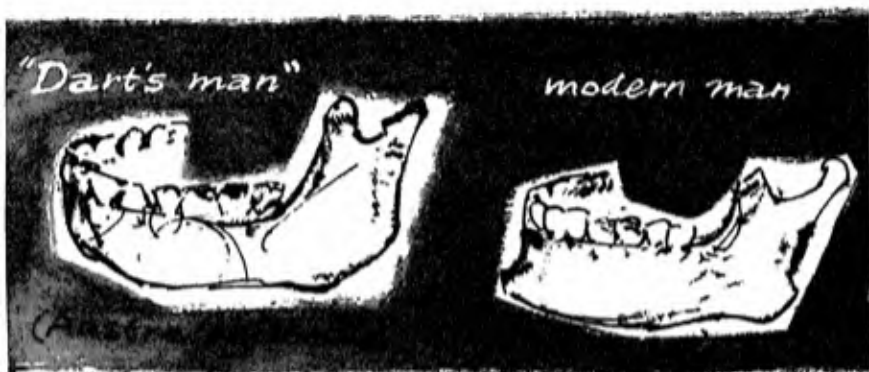
young chimpanzee. Just as boys' faces grow a little larger and heavier as they grow up, so do the chimpanzees'—only much more so. Was the smooth-faced creature of Dart's *really* smooth-faced—or just too young for heavy ridges to have grown up yet?



Why was Dart so convinced that this was not just a baby ape, but something far closer to us? One reason was the human shape of the brain. It was small, true enough, even smaller than the brain of a young child, but it was quite human in some of its fine details. It was possible to tell this because there was a very detailed cast of the brain. The whole surface and all the major markings on it could be made out.

Another manlike characteristic of this little apelike form was its canine, or eye, teeth. Apes really have *canine* teeth—they're long and pointed, almost like a dog's. They're so big there has to be a space between the teeth in each jaw to make room for the big canine from the other jaw, and these spaces

are clearly visible even when the teeth are missing, for the jawbone is smooth there instead of hollowed out as a socket for a tooth. Well, the jaw of Dart's little ape-man showed no such spaces; its canines must have been small ones like ours, not big like an ape's.



In a way the shape of the jaw was human, too. It does jut forward, much more than yours or mine. But the horseshoe curve of the bone in which the teeth are set is quite like ours. Our back teeth are further apart than our eye teeth, and so are the back teeth of this little skull. An ape's jaw has a different shape entirely. A set of ape false teeth would never fit a man, even if it was built to human scale. It would be much too narrow, and too long from front to back. It's not very clear just what the meaning of this difference is in terms of the use the teeth and jaws are put to, but the difference is there, and very useful to the scientist who wants to decide, "Just where shall I classify this particular fossil?"

By this standard, this ancient South African certainly belonged in a humanlike grouping, rather than in the camp of the apes.

And there was another, more exciting, human characteristic. The shape of the head suggested quite strongly that this little creature, unlike our great ape cousins, was fully erect, like you and me. There were no great heavy rear ridges for muscles to hold the head up. To Dart this meant that the little creature didn't need any, that the head was neatly balanced on the spine, an upright spine like ours. Apparently this creature from ancient Africa, although he had a tiny head and a jaw thrust forward like a chimpanzee's, held his head up just as we do. Surely that suggests that he walked as we do. Were his legs long and straight, and his arms, like ours, used for handling things with strength and delicacy?

Dart believed that the answer to all these questions was, "Yes." He was sure that this was one of our own early ancestors, a creature that had left the common stalk of our primate ancestry to climb out on our own separate branch. However, since this proposal seemed so daring and unacceptable, he was willing to compromise. He gave his little fossil form a neutral name—*Australopithecus africanus*, the southern monkeylike form from Africa—and waited for time and further discoveries to settle its status.

And so this little creature was entered in the lists as a contender for the title of "Missing Link" or "Earliest Known." Dart was sure he would win. But many others scoffed. They chose to emphasize the small size of the skull, the sloping forehead and the protruding jaw, which together give the face a long slanting line, so that the profile looks something like

that of a standard pet-shop monkey. They took to calling the little fossil "Dart's child," or the "Dartian." Since later finds have triumphantly supported Dart's judgment, the term Dartian has lost its slighting tone. We can even use it as a familiar, but friendly, nickname.

The new discoveries were largely due to the zeal and interest of Professor Broom, who was one of the few people to take Dart's fossil child seriously. He decided to look for further evidence. That was how he happened to be in Sterkfontein in 1938, when Gert stumbled on another member of the same family.

Professor Broom was originally a physician, not a paleontologist. But he was already making an important name for himself in his side line. He had even been summoned to America to settle a dispute about some bones—rat bones, of all things! He had made a very daring suggestion about that fossil, and it had stood up under further examination and comparison with new discoveries.

He proposed to be as daring in approaching this new primate fossil. He was certain that the Dartians were very ancient, and in the human line. And he saw that this put the whole picture of man's past in an entirely new light.

It took lots of hard work to bring the world of science into his camp. He won over General Smuts, who assigned him a kind of general fellowship in paleontology—a post that would make it possible for him to give up any further medical practice and concentrate on digging for man's ancestors. But South African scientists were not so convinced that he was qualified, and time after time placed obstacles in the way of his doing any actual digging. Still Broom

persevered. He was a rather peppery old gentleman by this time, and did not propose to be stymied by not having official "licences." And though his methods were unorthodox, his results certainly carried conviction. Gert's fossil ape-man was the second of his successful discoveries. Neither of these fossil finds was identical with the original Dartian, but both were enough like it to make Broom even more certain that Dart was right, and that ancient Africa had truly been the home of a very early ancestor of man.

He continued his search and his good luck lasted. In the mine areas around Sterkfontein, in shafts and caves abandoned when the mines moved on, almost everywhere he turned, he found more and more pieces of Dartians and their close relatives. By 1950 the weight of scientific opinion had to give in, and swing with him. Experts were finally agreed that these forms belonged somewhere on the human side of the fence. True, their brains were small. But they walked like men and were almost human in many other ways. They were certainly far more than just another variety of ape.

This made an important contribution to our understanding of man's beginnings. For before the Dartians were discovered, lots of experts thought that even the earliest manlike forms must have been creatures with fairly large brains. Since man's brain was his most distinctly human quality, it must be the one on which the rest was built. Besides, they argued, how could a puny creature like man risk life upon the ground before he had grown smart enough to outwit the other creatures, so much stronger and fleetier than he? The Dartians,

however, showed that man's progress had followed a quite different course. Brain expansion was the last decisive finale, not the first faltering step. When man had come down to the ground and learned to walk upright, with his hands freed for handling things, his eyes sharpened for seeing and examining small and delicate objects, he needed a giant brain. He had to take care of whole new sets of experiences and activities intelligently, or be wiped out. The individual whose brain was better equipped for this job had an advantage over his smaller brained fellows. Selection favoured growth of the brain, though there may have been other factors too that helped it along.

To say that man's giant brain was cleverer than that of a small-brained creature like *Australopithecus* is not the same thing as drawing comparisons between yourself and your neighbour on the same score. All human brains are relatively big compared with other animals', but they aren't all the same size. We wear different hat sizes, just as we wear different sizes in shoes or shirts or gloves. But there is no evidence that among humans big brains are any better than small ones. They all have the same pattern and the same twelve billions of cells in the grey matter. It seems that brains just have to reach a certain size to take care of all the human brain needs; beyond that, differences in size don't matter at all.

Australopithecus's brain was way below this minimum human size. Man's distinctive brain growth had barely begun in him. But he certainly was clever enough to use his hands and brain to supplement the strength of his arm and the swiftness of his limbs. Our ape cousins can throw stones, and poke at

things with sticks; they cannot talk or hand on a long tradition to their children, but Sultan, you remember, could invent a tool. And so no doubt could the Dartians.



There are pretty clear indications of some of this in the ancient homesites of the Dartians. For buried with them over the long, long ages since their time are the remains of many

associated animals who lived when they did—and must have died at their hands. All the fauna of a semi-arid, almost desert country are found associated with his bones—dassies, small baboons, springhares, giant moles, young antelopes—some of them kinds that live in South Africa today and others that have become extinct, just as *Australopithecus* himself has. And they are found, not just as associated fossils, that died as he died, but as piled-up bony debris, the remains of meals eaten long, long before the beginning of history. So—*Australopithecus* was a carnivore. He did not just eat bark and leaves and fruit, like our ape cousins. He ate everything, and anything, like us. But that means he had to live the life of a hunter, without the inborn heritage of a hunting animal—no sharp claws or pointed teeth, no vast powerful jaws, no horns or thundering hoofs.

There is only one way he could have done it. He must already have had some skills and equipment beyond the usual resources or habits of an ape. He did not need to make complicated tools—very likely he couldn't have. But he certainly needed to throw sticks and stones, not occasionally as for sport, but as a regular part of making his living. Did he dig moles out of their burrows with his naked hands, or—far more likely—with a digging stick? Did he learn to lie quietly in wait at a water hole—to capture food animals as they came to drink? Or perhaps join with his fellows for a drive on the swift antelope that would surely otherwise have eluded him?

Certainly his life ways were primitive. They were not the ways of fully human man who has left his wild state altogether to live by artificial ways. But they were the beginnings of such human living. *Australopithecus* not only walked

erect, he had already begun to walk in a human direction—along the path that is man's alone, the path of knowledge rather than habit.

But all this does not prove that the Dartians were our very own great-great-grandfathers. They would be very good candidates for the role, except for one thing. Many experts think they aren't nearly ancient enough, that they lived at a time when more advanced forms were already in existence in other parts of the world. If this is true, it would rule them out, because the least an ancestor can do is to be older than his descendants. Professor Broom doesn't think they're so young, though. He claims that they lived a full two million years ago. His time reckoning has been pretty sharply challenged. In fact, that's just what the South African scientific academy held against him when they tried to get him barred from digging. They said that he was messing up the stratigraphy—that is, that he was mixing up the layers in the ground by which age is indicated. However, he was able to show that unfortunately at that site there just wasn't any stratigraphy to mess up.

The truth of the matter is that we really don't know *how* old the *Australopithecus* fossils are.

And that's the whole trouble.

Dating is still a very tough job in Africa. The last million years, that are so neatly marked out into glacial periods in Europe and North America, aren't quite so easy to mark off in Africa. The glaciers never moved down into the southern hemisphere. Various ways of finding out the time relation-

ships between Africa and Europe are being worked on. But so far—the answers aren't in.

Meanwhile, what can we say?

If *Australopithecus* is a million or two years old, he may be our very own great-great-grandfather.

But if he is much younger, then he lived when there were already other creatures in the world who were far more completely human. In that case, he can only be a side line on our ancestral tree.

Still, even if *Australopithecus* isn't our very own great-great-grandfather, he gives us a clear picture of what our own ancestors must have been like way back in the dimmest dawn of human times.

9.

BURIED TREASURE IN JAVA

THE next chapter in our story takes us to Asia.

The ape-man from Java is far more human than his grandfather—or uncle—or cousin—from South Africa. *Pithecanthropus erectus* is a far more recent ancestor of ours, but we've known about him for a much longer time. He held the title of man's oldest ancestor for nearly thirty-five years, before the Dartians came along to challenge it.

Back in 1891 when he was first discovered, "the ape-man who walked erect" was the most primitive almost-man on record, the first real proof to many people that Darwin was right, and that man really was descended somehow from an apelike ancestor.

The discovery of *Pithecanthropus* was not just a lucky accident. A young Dutch doctor deliberately set out to find such a "missing link," and unlike most treasure hunters, actually succeeded.

Eugene Dubois had read Darwin's book on evolution while he was in medical school. He decided that somewhere in Asia or Africa there must be fossil forms that would link man to

his animal ancestors. And he was determined to find this evidence that Darwin was really right.

At first he tried to get the Dutch Government to finance an expedition to the East Indies to conduct the search. But no one would take him seriously. When he realized that no one would back him, he decided to do the job himself. He gave up his comfortable and promising career as a teacher of anatomy, and took a job as an army health officer, assigned to the colonial service. He had no special interest in digging drainage ditches, or administering castor oil and poultices to natives, but the job would take him to the scene of his hopes.

The work of an army doctor was very strenuous for a quiet young scholar. But every moment he could spare from his regular duties found Eugene Dubois working even harder. Instead of relaxing at cards like his comrades, he spent all his spare time exploring, digging in the beds of ancient rivers, and examining the rocky cliffs that lined their sides. He had no map of buried treasure to go by. All he had was a hunch. But it was a scientific hunch, and it paid off.

First he located a region rich in the fossil bones of all sorts of long-ago, extinct creatures. There was a huge tortoise with a shell seven feet long that had weighed nearly two tons when it was alive. There was a strange nightmare creature called the *chalcothere* with a body like a tapir, the head of a horse, and long front legs with enormous claws instead of hoofs. There were tiny camels and elephants. Dubois carefully collected all these fossils. He was not so interested in the story they had to tell as in their suggestion that this was really a good site to explore. If other long-ago forms had left their remains here, why not ancient man?

These fossil riches finally persuaded the authorities that Dubois might really be on an important track, after all. They decided to relieve him of his routine duties, and leave him free to pursue his strange self-chosen task. For many months he worked on, and at last his devotion was rewarded. Eugene Dubois actually found his fossil treasure: not gold or jewels, but the bones of an ancient creature who was nearly human—and yet not quite human—exactly the sort of “missing link” he had set out to look for.

Even now his success seems almost too good to be true. Whole expeditions have looked just as long, in places just as promising, and met only with disappointment. But Dubois had really come upon something all by himself. No wonder the world at that time was startled—and sceptical.

The long-ago creatures to whom these fossil bones belonged seems to have met his death in the eruption of an ancient volcano. His bones were preserved in a flow of lava and ashes which engulfed him in a river of melted rock, just as Pompeii two thousand years ago or Italian villages in recent years were buried under flows of lava from Mt. Vesuvius. We can imagine him and the other creatures of his day attempting to flee from the smoky, sulphurous death that poured down the mountainside. But the very lava flow that killed them preserved them for us. Torrential rains that swept the countryside washed the preserved remains down to the shores of the Solo River, scattering the parts, and then burying them under layer after layer of sediment which since have hardened into rock. The river has cut a channel through these layers of rock just like the rivers in the canyons of our own West. Today, there are often floods here during the rainy sea-

son, and the river rises over its old banks. When it subsides, lots of the old buried fossil material lies uncovered, washed out by the flood.

It was in the midst of all this fossil wealth on the banks of the Solo River that Dubois found his important treasure—the remains of one of our ancient great-great-great-grandfathers—or granduncles. Of course, he didn't find all of him.

*Excavating for fossil remains
near the riverbanks in Java.*



Just a few of the toughest bones had survived. He didn't find these all in one place or all at one time. They had been scattered about a little by all that had happened to them over the years. The first part that he found was just the top of the skull. We can well imagine his feelings the day he came across this particular fossil among the many bits of animal bone he was digging up and sorting out, and recognized it as a humanlike skull that might well be as much as a million years old!

Perhaps one day we shall find out exactly what his feelings were, for Dubois kept a careful diary of his work. It is now in the museum in Leyden, and no doubt it will eventually be published. Meanwhile, we do know that he worked on with renewed enthusiasm, and with great care. A Dutch anthropologist who has been privileged to read his diary says that the methods Dubois used were as careful and exact as those of the best modern field workers.

Before the year was out, Eugene Dubois had found some more pieces of the broken skull, pieces that fitted together to make a complete skullcap. He also found part of a lower jaw and some teeth. From all of these he could picture a creature with a beetling brow and a receding chin—a creature that was neither man nor ape but somehow in between. And then, months later—about fifteen yards away from the original site—he found something else. He found a long, straight thighbone, the thighbone of a creature who almost certainly walked upright and held his head high, like a man.

Dubois had been looking for exactly such a creature, somehow more than ape or monkey, and yet not quite a man. He even had a name ready for him. The name *Pithecanthropus*

had been coined by a philosopher friend of Darwin's for such a missing link. *Pithekos* is Greek for monkey, and *anthropos* is of course man, as you know from the word *anthropology*, the study of man, of which all this is a part. *Pithecantropus erectus* he was, then—the ape-man who walked erect.

Painstakingly Dubois separated the bones from the surrounding stone in which they were embedded, and proudly, in 1895, having published a preliminary outline of his great discovery, he went back to Holland, to a quiet scholarly post in a museum, bringing with him his precious ape-man, and hundreds of other fossils, some still encased in lumps of stone.

There was no radio in those days to blazon forth Dubois's discovery to the world. Newspapers didn't carry big headlines as they would today: "Missing Link Found in Asia," "First Man One Million Years Old, Scientist Claims," and so on. Still, word did get around, very excited word, and by the time Dubois sailed back to Europe he found he had sailed into a terrible storm. People just refused to believe that he had really found an ape-man. They thought that he must have just found some diseased monster that belonged in a freak show, or that his description was wrong and this was an ordinary ape. They tried to shut their eyes to the material and just say, "It isn't possible and it isn't true."

It wasn't that no one else had ever heard or thought about a missing link. As a matter of fact, the idea was very popular. People argued about it, and they made lots of jokes about it. The New Orleans Mardi Gras had even set "The Missing Link" as a costume theme some years before, and weird hairy creatures, with caricatures of faces and monkey tails draped

over their arms, had danced in the streets to represent it. The term "missing link" was as familiar as "superman" is today, or "spaceman."

But—it's one thing to write stories and comics about such a creature; it's quite another to meet one! Just suppose someone offered to introduce you to a man from Mars in person. Somehow it wouldn't be funny any more. It might even be frightening to think about. Certainly if someone just claimed to have found the skeleton of a Martian, we wouldn't rush to believe him. We would look mighty hard for some other more likely explanation for what he claimed to have found.

So it's easy to see why the man in the street, the newspaper editors, the clergymen were shocked and startled to hear Dubois claim that he had actually found a real missing link. The whole idea of evolution was still a new and dangerous one to the average person.

But scientists should certainly not have been shocked at Dubois's find. They had been talking about evolution for a hundred years. They knew and respected Darwin's work, which had been published more than thirty years before. Biologists, geologists, philosophers were well agreed that man had had less-than-human ancestors, that these ancestors had begun the long climb to man's estate long, long ages before.

Still, this was the first actual evidence of one of these really early stages. Dubois's find fitted very neatly into Darwin's outline story of man's development. But—scientists couldn't just take it for granted. There were lots of legitimate questions about it that had to be answered. Even if the scientists

were sympathetic and interested, they had to ask: "Was it certain that these bones were as old as the other fossils in that river bank?" "Had Dubois read the story that they told accurately?" "Was it clear that the various bits were all part of one creature, not just mixed-up parts of an ape and a man?" "Was the strange, heavy-faced, low-brow skull that of a typical creature of those days—or perhaps some strange freak?"

Dubois had perfectly good answers he could give to many of these questions. But somehow he was not ready to take on the fight. Nearly fifty years earlier Boucher de Perthes had fought hard to have old stone tools recognized as evidence that man had lived in Europe for tens of thousands of years. He had finally won his case in 1861, when a formal scientific delegation came from England to examine and certify his finds. But Dubois was not ready to go to bat in that way for his Javanese ape-man. We don't know just what his reasons were—how much he was hurt and angry at the personal attack, how much actual doubt and confusion he felt in the face of all the scepticism. In any case, he did a very strange thing. He withdrew all his finds from public view, locked them away in a museum in Holland, and for nearly thirty years allowed no one to so much as see them again.

Meanwhile, the temper of the times was changing. Darwin's theory of evolution was being widely accepted. Finds of ancient man were being made in Europe that left no doubt that earlier forms of man had once existed. By 1920, *Pithecanthropus* was no longer alone. There was *Pittdown man* and *Heidelberg man*, staking claims to be our very

early ancestors, and Neanderthal man was becoming quite a familiar figure. Scientists were ready to examine Dubois's finds without prejudice, to see just where his ape-man or man-ape really fitted into the whole picture of man's development. But—the doors of his museum cases were locked up tight. There was nothing to go on but his first published reports.

This was certainly not to be borne. Scientists were struggling with tiny scraps of evidence. Every tooth or bone of a fossil form had to be read like a three-volume work on the life and times of Mr. Ape-Man X. And here was a whole library locked away! The Dutch Academy of Science argued with him. Scientists from all over the world pleaded with him. Finally Dubois yielded. In 1923 he agreed to let the American anthropologist Ales Hrdlicka come and see the fossil bones of *Pithecanthropus*.

Now Hrdlicka was already famous as a debunker. Time after time his reports had demolished the claims of various skeletons to be our long-lost ancient grandfathers. But Hrdlicka was impressed with Dubois's ape-man. He agreed that the fossil bones were very ancient, and that they certainly were the remains of an extinct manlike creature, someone who really fitted into an important place in the puzzle picture of man's past.

Hrdlicka's opinion carried weight. *Pithecanthropus* was accepted as a respectable member of man's fossil ancestry. Casts were made of the parts so that museums could display them and scientists all over the world could study them. A careful picture was built up from the forehead bones and the parts of the skull cap that showed what *Pithecanthropus*

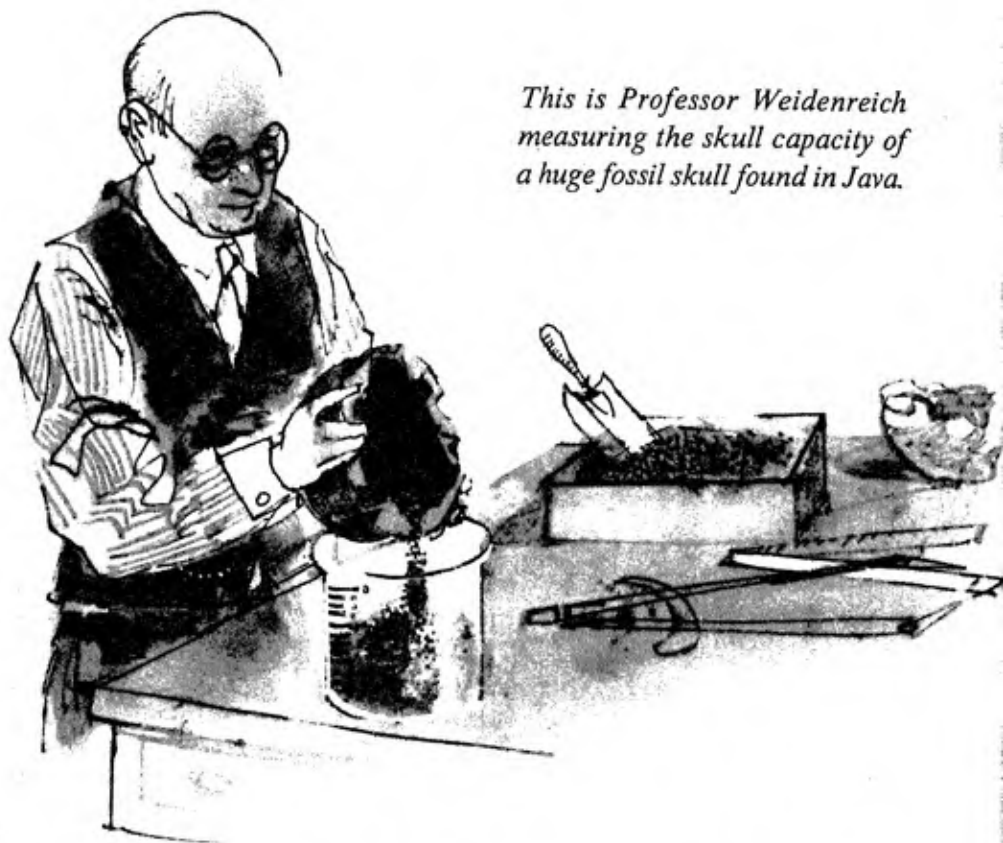
must have looked like. He had a very low, sloping forehead and large bony ridges over his eye sockets. Nonetheless, his face was far more human than apelike. And his head was hinged onto his neck in almost human fashion. What is most important, it was humanlike in size. True, it was much smaller than yours or mine, but it was larger than that of the largest gorilla.

Of course, a gorilla's head looks as though it were much bigger than a man's. But it isn't, at least not on the inside. And it's the inside that counts, because that's where the brains are.

The gorilla's head is big on the outside because he has such heavy muscles. Great crests of bone have to grow up on the skull to hold these muscles. That is something that actually happens during the lifetime of each individual gorilla. Experiments on other animals have shown that crests like these grow as the muscle is used, and don't grow at all if the muscle is destroyed. Because of the huge muscles and crests of bone the gorilla's head looks huge, but that look is only skin—and muscle—deep. The skull itself is far from spacious. It's musclebound, rather than brainy. In fact, the *inside* of the brain case of the largest gorilla that has ever been measured is only about half the size of an average man's. Since his body is bigger, his brain is proportionately smaller. (For those of you who like statistics, man's brain is one fiftieth of his total body weight, while a gorilla's is only one part in a hundred and fifty.)

Measuring the inside of the brain case is about the only way the anthropologist has of finding out how big a brain was. He can only study the brain itself when it is very freshly

This is Professor Weidenreich measuring the skull capacity of a huge fossil skull found in Java.



dead. Otherwise, he has to be content with knowing the "cranial capacity"—the volume of the inside of the skull. That tells him how big the brain was, because *what* the skull holds is brains; it's chock full of them.

To measure this "cranial capacity" the anthropologist turns the skull upside down, stops up all the openings—eye, nose, and so on—and then fills it level with some material like BB shot or round grain. This he then pours off into a measuring cup—and there you are!

Of course, this method is no use in measuring the size of the brain of a living person: there one can only make an estimate from the measurements of the outside of the head. So you'll not be able to try this technique on yourself and your friends. But by comparative measures of many modern skeletons, we can safely say that when you are full grown, your skull will measure something in the neighborhood of 1500 cubic centimeters, which is a little over a quart and a half.

Measured in this way, the carefully reconstructed skull of *Pithecanthropus* holds about 900 cubic centimeters. He apparently had just under one quart of brains! That's smaller than the brain size of any modern type of man or woman, even a pygmy. But it's definitely larger than that of any modern ape. To judge by his head, *Pithecanthropus* was not quite human, but he had come a long way toward that status.

On the other hand, one of the features of *Pithecanthropus* that doesn't seem to have been "in between" at all was his posture. The thighbone that Dubois had found was long and straight. The full "head" of the bone was missing—the round ball whose angle would have shown most positively how the femur was fitted into the hip socket. But down the back of the bone was a long line for muscle attachment exactly like the one on your thighbone—or mine—and not to be found on the ape, whose legs don't ordinarily carry the weight of his erect body. And the skull carried further evidence of the same point. The balancing place where the skull fits into the spine isn't preserved. But it must have been tucked well under, as it is in our own heads, because the ridges for the

muscles in the back are small. If the head was not exactly balanced, the muscles would have had to be larger, to hold it in place, and their attachment places would show this quite clearly.

When Dubois made his claim that *Pithecanthropus* had an "in between" head, but stood erect, many scientists were sceptical. They didn't think that posture changes should run ahead of head changes that way. Many thought the thigh-bone was not part of the same individual. Or that it was long and straight because it was like a *gibbon* rather than like a man. Even Dubois's opinion was rather shaken on this point, so that forty years later, when he began to show his finds once more, and even to lecture on them, he himself had swung to that view.

It's rather ironic, though. Because by that time *Australopithecus* had been discovered, and showed even more clearly that erect posture could come first.

Only, of course, you remember—back in the 1930's people were still being sceptical about *Australopithecus*! Now that he's been so well established, there need be no doubt about *Pithecanthropus* on that score.

But there is better reason for being sure about him. As a lone specimen, there would always have to be questions—about his position, or the date, or the reconstruction of some part. But Dubois's specimen is no longer alone.

It was obvious long ago that more evidence was needed. In 1905 an expedition went to Java to try to find some, but was unsuccessful. That was rather discouraging. However, in 1940 a young Dutch scientist—Gustav Heinrich Ralph

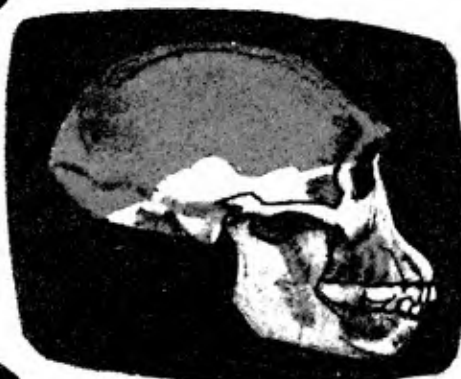
von Koenigswald—decided to try again. He went to work right at the same site where Dubois had made his finds.

The Solo River was still yielding a rich fossil crop after every rainy season. As a matter of fact, the fossil riches there were so great they almost proved embarrassing. To save time



Gorilla

Pithecanthropus
(grey portion is the
original skullcap)



Homo sapiens (us)

and cover more ground, von Koenigswald hired native helpers to bring to his laboratory all the exposed fossil bones they could find, of whatever sort, at so much per bone. Tens of thousands were brought in, and among them a very tiny proportion proved to be human.

At first, the human bones were all remains of men of a much later date than *Pithecanthropus*. They were more nearly modern men. But one day a native collector brought in what appeared to be a piece of a skullcap of about the same age as Dubois's original *Pithecanthropus*. Von Koenigswald was delighted, and excited. Rashly, he offered a special bonus for every further piece of that kind that could be found. In the course of the next two days, a whole skullcap was brought into the laboratory—but—it was brought in broken into many pieces—for so many separate bonuses! Fortunately, it is not difficult to mend such neat new breaks, so the damage could be repaired. The skull was quickly re-assembled, and went into the record as *Pithecanthropus* II. When it was compared with the skullcap of Dubois's ape-man, it was found to be "as like as two peas in a pod."

Von Koenigswald went on working and finding more interesting material. *Pithecanthropus* III and then *Pithecanthropus* IV joined the company of man's ancestors. And then came the outbreak of the Second World War.

When the Japanese invaded Java very early in the war, von Koenigswald and his family were all interned for the duration. They were not even allowed to communicate with the outside world. Von Koenigswald was afraid that the

Japanese would confiscate the precious fossils in his laboratory. As a matter of fact, they did send one fossil skull to the Emperor for a birthday present, but it was one of the later human forms. He devised a brilliant plan for safeguarding his valuable fossils. He removed them all and hid them in kitchen cupboards and similar unlikely places at the homes of friends. Then he took the plaster casts which had been made of them and locked them carefully away in the office safes. They were assumed to be the originals, and left undisturbed. The true originals remained safely hidden until after the war.

Dubois had called his fossil men *Pithecanthropus erectus*, "the ape-man who walks erect." Because this name has become traditional, von Koenigswald has continued to use it. But he does not think it is really appropriate. Dubois saw his man as a missing link between ape and man. Von Koenigswald, however, is impressed with his manlike characteristics. He points out that *Pithecanthropus* had left any ape ancestry far behind. He would rather call him a primitive species of man than an ape-man.

Just where does one draw the line and say, at this point we have a man—not *Homo sapiens*, perhaps, but a related species? How can we tell a man from some simpler form that is just on its way to becoming a man? The answer is almost just a matter of taste. Some would draw the line at the point of upright walking. That would make the Dartians men, and here almost everyone would balk! *Pithecanthropus*'s claim rests on the beginning of human brain expansion, which he shares, but does not carry very far. Most experts

would not be ready to accept this. They want some tangible evidence of really human intelligence. And as yet we have no sign of any tool remains associated with this ancient form from Java. And so they usually label him today not Homo, but an "almost-man," much farther along the road to us than a mere "ape-man" like Australopithecus.

10.

A TALE OF THE CHINESE HILLS

ONE of the important things that convinced von Koenigswald and other scientists that *Pithecanthropus* really belongs in the early-human fold is another Asiatic fossil man that turned up nearly forty years after Dubois's first discovery. This is Peking man—very like *Pithecanthropus* in many ways, and yet more definitely manlike.

The story of Peking man really begins in a Chinese drugstore. In China, old-fashioned half-magical remedies for many illnesses were in use until recent times—just as they were not so long ago among our parents and grandparents. If you've read your *Huckleberry Finn*, you'll know that our quite recent forebears bought "snake oil" and "Indian herb" remedies as cure-alls for all sorts of things, from backache to consumption. In China, a favourite general cure-all of this sort, believed to be very powerful indeed, was made from powdered "dragon bones." When other, lesser remedies proved ineffective, this could be counted on to help in almost any sickness. And so in every drugstore "dragon bones" were sold along with other drugs that ranged from ginger-

root and camphor to tiger claws, lizard's blood, bat wings, and other things that sound like the witches' brew in *Macbeth*.

Now what do you suppose these "dragon bones" are? Nothing else but fossil bones of any and all kinds! Whole families in China have made their living for generations digging up such fossils from rich beds of limestone, particularly in the area just north of Peking.

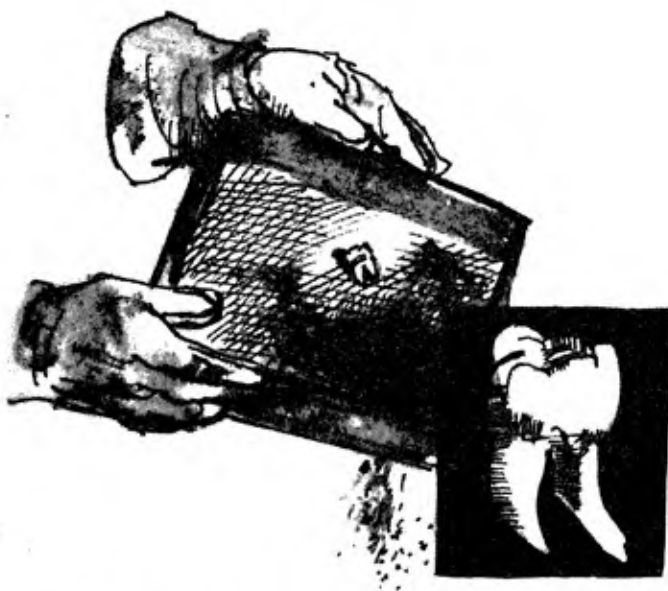
In the 1920's, when the interest in early man was beginning to grow, and *Pithecanthropus* was being established as a reputable member of man's fossil ancestry, other parts of Asia began to appear well worth exploring further for similar ancient forms. A Swedish geologist, Dr. J. S. Andersson, decided to explore this area before it was all mined out. With the support of the Chinese Government and extra funds from Sweden and the Rockefeller Foundation, he began to comb the area around Peking for traces of ancient man or man's ancestors. This area is rich in promising limestone caves, but it is also quite vast. It might have yielded nothing but more "dragon bones"—dinosaurs, perhaps, or the extinct relatives of camels and elephants—for quite a long time if Andersson hadn't found a special clue that narrowed the search down in a very dramatic way.

The clue was a simple one. It wasn't human bones, nor even any ancient human tools or weapons. It was just a few pieces of raw quartz. But the significant thing about these bits of quartz that caught Andersson's trained geologist's eye was the fact that they were out of place. Though they were deep down in rock layers that were hundreds of thousands of years old, they just didn't belong there. They weren't part

of the rock formation of this region at all. Somehow they must have been carried there, and there's only one kind of creature who does that sort of thing: a creature who can use such bits of stone for cutting things, or perhaps even sharpen them into actual tools. Andersson looked at the quartz, and made an immediate decision to set up camp right there at Choukoutien, about twenty-five miles southwest of Peking. "Early man lived here," Andersson declared. "Now all we have to do is find him."

And so they set to work. This was no one-man job. There were scientists with various skills coming from many different parts of the world—China itself, Sweden, Canada, Germany There were geologists to study the sites, paleontologists and anatomists to work with the bones, specialists in ancient animals and specialists in ancient bones. The search took years of their combined patience and skill. But it was successful.

In the late summer of 1926 a single tooth was found; it was pretty certain that it was the tooth of a young child, about nine years old. It wasn't enough to draw any conclusions from—except the important one that ancient man of some sort had indeed lived here. The tooth was taken back to Sweden, and the work went on with renewed energy—in spite of increasing obstacles. Some of these were obvious difficulties that came from working in a region where the cold set in early, and the base of supplies was far away. Dr. Birgir Bohlin, who made the important finds more than a year later, told newsmen how he had to dig carefully with his numbed fingers, and then warm them over a charcoal brazier so he could dig once more. His wife—they were newly married—



would come out from Peking on the rough mountain roads to bring him fresh food from time to time; in between, he made shift as best he could, because he knew that he must hurry, and not let anything delay his work. For the winter that was setting in was not the only hazard. The Chinese civil war had flared up, and was closing in on their working sites. Armed troops—and armed bandits, for China was full of bandit groups who were taking advantage of the generally upset state of things to do some private pillaging—would pass by Bohlin's camp and watch him at work. At any point, his tools and supplies might have been confiscated. His very life was in danger.

In 1928 he was ordered home to Sweden. Reluctantly, he closed up his camp. Tools and equipment were packed, ready to go. On the evening of March 23 they were ready to leave for Peking. There was just a small pile of loose sand and gravel that had already been dug up out of a long vertical

crevice in the rocks but had not yet been examined. While the others waited, Dr. Bohlin decided to finish up by sifting this last bit through his mesh strainer. And there, in this pile of rubble, he found another little tooth, stained brown with mineral deposits—an ancient human tooth, the first he had been lucky enough to find.

Carefully Bohlin put it in his vest pocket and started back to Peking. Missionaries were being captured and held for ransom. Many Europeans were being evacuated. The situation was extremely perilous. But Bohlin was determined to protect his find. Twice on the way he was stopped by bandits, who looked for supplies and money—but overlooked a trifle like the little brown tooth. They found nothing of value on him and let him go. Proudly Bohlin delivered the tooth to Dr. Davidson Black, the Canadian anatomist who was in charge of the laboratory work in Peking. Black set to work on the tooth, examining it minutely in every way, and comparing it with everything that was known about human and ape teeth, fossil and living. Day after day, night after night, he pored over it. It was little enough to go by, but Black decided that that little was clear enough to gamble on. Risking his scientific reputation, Black decided he would declare this tooth human, a member of a distinct species, a not-quite-modern Chinese species, that he named *Sinanthropus*—the Chinese human form.

Later developments fully supported him. In the course of the next two years—in spite of gunboats standing off the coast, and the increased tempo of the war, the work went on—Dr. W. C. Pei and two other Chinese scientists finally recovered a skull. This was quickly followed by the remains

of quite a number of other individuals. Within a few years the Chinese ancient was a well-known and well-established figure.

The laboratory continued to operate until the time of the Japanese attack on Pearl Harbour. Davidson Black, though still a young man, died, and his place was taken by another great and rather daring anatomist—Franz Weidenreich. He was a German, made available for science elsewhere by Hitler's presence in Germany, one of the many refugees whose work has enriched the world of science. When the Japanese attacked, Weidenreich arranged to leave for America. This time the fossil valuables were not so lucky. They were scheduled for removal too, and were to be put aboard an American Navy ship, but somehow the transfer didn't work out, and they disappeared—somewhere in China. And they have never been found. No one knows what became of them—whether they were blown up, or have just been hidden away where they may yet come to light. Fortunately, Weidenreich had his working casts of all the material with him, and so the work of studying and comparing these finds has been able to go on, though not as fruitfully as if the fossils themselves had been available.

What was this Chinese great-great-great-grandfather of ours like? In some ways, his description would be very much like the description of *Pithecanthropus*. Of course, he walked upright. Heavy bones, great beetling brows over his eyes, a low sloping forehead, lower than that of the worst caricature of a lowbrow you can imagine, a heavy protruding mouth region, not a muzzle, but a little like one, and under it a low re-

ceding chin, again worse than a caricature's weak-willed Willie. A small head, compared to yours and mine—even compared to that of a five-year-old child. And yet—far more “human” than *Pithecanthropus*. In all these things, he had moved farther along toward the large expanded human brain that marks off modern man. He had a larger head, a higher forehead. He had somewhat more chin, too, and even that is important.

Men and apes have very different chin regions. Apes have more jaw than we do—huge teeth, great rubbery lips that can stretch out to form a big cup—and their jaws go way out beyond their noses. But below the heavy teeth, the jaw slopes backward, instead of jutting forward. Man has a smaller jaw. But below it is a bump that sticks way out. That's what you call your chin. Some of the muscles for moving your lower jaw are attached there. If you put your finger on your chin, you can feel the muscles moving when you purse up your lips and make other facial grimaces.

The apes have quite a different arrangement. *Their* muscles are attached *inside* the mouth. They're attached to a little shelf of bone inside the lower jaw—in front, right below the teeth. We don't have this “ape shelf,” so we have lots more room in our mouths—more room for our tongues. This may not be essential to speech, the way brain development is, but it certainly helps it along. Neither *Pithecanthropus* nor *Sinanthropus* has any sign of such an apelike ledge inside his jaw.

Sinanthropus—more properly *Homo* something or other—was human, all right, though certainly he had not moved all the way along to full modern status. He was beginning to live



like a man, too. And that is another important indication. The Chinese Geological Institute that discovered him has learned a great deal about him. They know he lived in caves. And they know that he used fire. He ate great quantities of berries, and left huge piles of their seeds behind. And he ate meat—*cooked* meat. The great apes are mostly just vegetarian, unlike their lowlier monkey cousins who also eat small

insects, eggs, and such other meat foods that are available to them in the trees. But man seems to have been omnivorous from way back—that is, an everything eater (*omnis* is Latin for all, and vorous comes from the same Latin word you find in English words like devour).

We aren't quite sure how an early man like Peking man actually killed his prey; perhaps for some of the larger animals whose bones we find in his caves he didn't do his own killing. He may have collected the remains of animals killed by stronger and fiercer beasts than he, like the sabre-toothed tiger that lived in eastern Asia when he did. But we know he ate deer meat and such when he could get it. For like men in many parts of the world since that time, when he ate meat, he roasted it over a fire, and this often charred the ends of some of the bones. Very often he split the leg and arm bones lengthwise, in order to extract a special food delicacy, the bone marrow. And to do this he had to use a sharp tool of some sort. Other animals like bone marrow, too, but they have to get at it by gnawing from the end. Only a very humanlike hand using a tool can manage to split the bone lengthwise as the bones that are found in the cave homes of ancient Peking man are split.

Peking man had another habit that may seem to some of you a little gruesome—but it is undoubtedly one that man has long been guilty of. Some of the skulls found there in the caves—human skulls—are nearly perfect, except for the fact that their bottoms appear to be bashed out. Not their tops, as might happen by the living man's falling or being hit by a club, nor just their fragile bones; it's the bottom that's gone, and it seems to have been deliberately removed. Of course,

this may only have been a way of turning the skulls of friends—or perhaps enemies—into ceremonial drinking cups. But perhaps that wasn't all. For there are people who used very similar ceremonial drinking cups until quite recent times, and they prepared the cups not just by breaking out the bottoms, but by eating out the brains. It may seem a very savage kind of thing, but I'm afraid it's also a very human one. We are more widely guilty of cannibalism than almost any other mammal.

It is clear, then, that a creature who was almost-man lived in Asia perhaps a half million years ago. He seems to have been a slightly more advanced form than *Pithecanthropus*, but closely related to him. Was he our own ancestor? Perhaps. But perhaps not. Only more data will tell. It's quite likely that he was related to us through another somewhat more modern form with beetling brows who is known as Neanderthal man. But Neanderthal man's own status isn't altogether clear!

You're about to meet Neanderthal man. But before I introduce him, we shall have to take time out briefly for a special mystery chapter in our history.

11.

GIANTS?

*D*O you believe in giants?

Suppose I were to begin this chapter, "Once upon a time, before man became a fully human being, giants walked the earth. Slowly, they learned the ways of men, to use their wits instead of brawn, to cook their meat instead of gnawing it from the flanks and legs of their prey. Their teeth and giant muscles shrank as the giants stopped depending on them, and so we, their puny descendants, are shrunk to modern size, giant in nothing but our brains."

Would you think that I was just joking, or telling a tall tale?

Well, this is one of those cases where it may be that fact really is stranger than fiction. The story may not go exactly as I've just outlined it. Perhaps the shrinking came first, and the cooking and weapons had to follow to make up for the smaller size of bones and muscles and teeth. And perhaps the giants weren't our very own grandparents, but just our granduncles, side branches on the tree of man's development.

But giants of some sort, it seems, there really were, once

upon a time, probably a few hundred thousand years ago.

We don't really know how tall these ancients were. Mostly we know their teeth. And what teeth these were! Several times as big as the huge ones of our gorilla cousins. But they were quite human otherwise, in their general shape, and in all their bumps and ridges.

The first indication of these giant teeth came from the same Chinese drugstores that had given the clues to Peking man. Before von Koenigswald went to Java, he worked at the biological laboratory in Peking. He used to haunt the drugshops, hoping to turn up some keys to early man. That was how he found these "giant" puzzles. But these teeth are not the only hints of long-ago giants. Among his later Java finds, one, at least, has a massive bone structure way out of line with the others. There is also the ancient European jaw that was found near Heidelberg in 1905 whose huge size has always been a puzzle, and there are other big-jawed fellows from South Africa.

It would be comfortable to brush these scattered finds aside and say, "So what. They're just odd." But that's what people said about Dubois's *Pithecanthropus* and about the first ice-age men, and now we know they were wrong. Most anatomists prefer to say, "They're odd, but they *are*, and so they have to fit in somewhere. However, we need more data before we can interpret them." And that makes very good sense. Because we can't really tell whether these big teeth necessarily mean over-all giant bodies. Perhaps they just mean that the creatures who were becoming men once upon a time had huge heavy faces.

One man has been willing to go pretty far out on a limb to make a place in our ancestry for the men these jaws and teeth belonged to. That is Franz Weidenreich. Many other experts do not agree with him. But Weidenreich is an anatomist whose word deserves at least to be listened to. He is the man who most nearly saw through Piltdown man. And it is he who worked out much of our understanding of the Asiatic fossils.

Unfortunately, Weidenreich is dead now, and in some ways it's harder to argue with a man's memory than with the man himself.

So, without taking a stand, we'll just explain his opinion as he set it forth in scientific papers and also in a little book for laymen to read, *Apes, Giants and Man*.

Briefly, what Weidenreich argued was that size changes take place fairly often in animal forms. There have been tiny camels, and horses, and even elephants. And during parts of the ice ages there were also giant creatures of many of these families—the mammoth, for example, and the giant sabre-toothed tiger. Perhaps there was something in the living conditions of the middle ice ages that promoted such growth. In any case, Weidenreich insists, to judge by the fossil teeth and pieces of jaw, man's ancestors too had such a period of expanded growth. And so we find giants in Java that he thinks may have been ancestral to Java man and the other Asiatic fossils, and the same was probably true in other parts of the world.

Weidenreich believes these giant men must have been huge to match their jaws and faces, and their skullcaps must

have been massive too, big enough to hold a pretty big brain, as big as our own—even though it was much smaller than ours compared with total body size. And then—and this was a most important development—these giant men grew smaller. Their faces shrank. Jaws grew less massive, and the

*The Pekinese has
a small face tucked under
a high flat skull.*



face folded in under the brain case. But the brain case itself did not shrink. Thus man as he became fully human retained the giant brain of his giant ancestor! Weidenreich didn't make this idea up out of whole cloth. He pointed to similar happenings in other animal families. The Pekinese dog, for

example, has a flat muzzle compared with other dogs. His small face is tucked in under his skullcap just as man's is. And he too has a brain case that is large for his size, and high on top as well.

So much for Weidenreich's theory. Status is—unproven. But not disproven either. Perhaps the "giants" were just men with heavy jaws and huge teeth. Or, perhaps they were huge in all their head and face parts without being especially tall. Since we don't really know, let's just put the whole problem into the filing cabinet for the time being, in the rather plump folder labelled "Decision Pending."

Meanwhile, we can turn our attention to fossil forms that are better known, and bring the story up to modern times.



*Did we once have
a giant ancestor
like this?*

12.

NEANDERTHAL MAN

SOME hundred thousand years ago or a little longer, before the great glacial icecap moved down from the north for the last recorded time, there lived in Europe a creature who is better known than any other fossil human, or near human: Neanderthal man. Everyone has heard of him, and almost everyone has some idea of what he must have been like. In popular thinking, Neanderthal man was the real-life model of the cave man that we find in the comic strip—an apelike figure, with a thick neck, and long arms like a gorilla, dressed in bearskins. Usually, he clutches a war cudgel in one hand, and drags his wife by the hair with the other.

Of course, this is a most exaggerated picture. That's not surprising. Perhaps it is more surprising that it actually contains some grains of truth.

As a matter of fact, Neanderthal man was not, properly speaking, an ape-man in any sense. He was much too close to us for that kind of term to be applied to him. One anthropologist has shown this very neatly. He tried the experiment of drawing a picture of Neanderthal man dressed as a mod-

ern American instead of a semibrute. He drew him with his face clean-shaven, his hair cut, wearing a hat, and a collar and tie. He came out rather ugly, it's true, and maybe he would have had a hard time finding his head size in stock at the hat shop. But he would probably have passed without too much notice in a crowd.

The very first Neanderthal skull on record turned up near Gibraltar about a hundred years ago. That was before Darwin's book on evolution had appeared. The question of man's relation to other animal forms was not a subject for every man's interest. Old animal bones were still being treated as

remains of creatures that had perished in the flood. It was taken for granted that any human bones found among them were there because someone just happened to get buried there, much later on. People were even sceptical about the remains of old stone tools. So when this first not-quite-modern human skull turned up, no one paid any attention to it. It was tucked away among other curios—fossil starfish or quaintly carved ivory tusks—and forgotten. It wasn't until many years later, when



*Perhaps he would
look like this!*

other Neanderthal finds had already been reported, that this one was rediscovered. It was taken down from its shelf, dusted off, and put into the record.

The fossil that gave its name to all these early European relatives of ours was found in 1857 in the valley of the Neander, near Düsseldorf. Workmen quarrying limestone in a cave came across some remains of human bones. They tossed them into the pile with the rest of the debris. What could be interesting about a lot of old bones? Fortunately, the owner of the cave realized that very old bones might be even more exciting than the hidden remains of some recent murder victim. He had the bones collected, and turned them over to a scientist. They were somewhat broken up by that time, and their position in the rock was no longer clearly indicated, but they were certainly very old, and most unusual. They were not quite like any human bones that had ever been seen before.

By this time evolution was becoming a burning issue. You would think that someone would have said, "Look, an earlier, and a *different*, form of man. Let's see what he can tell us about how we developed."

But that isn't what happened. The differences were plain enough. The skull had thick beetling ridges over the eyes; the bone was much thicker than that of any ordinary man; and the forehead was so low and sloping as almost not to be there at all! But the scientists of the day weren't at all prepared to say what this might mean. Virchow, who was a famous anatomist, said, "Obviously the skull of some diseased idiot," and that was typical. Darwin's friend Huxley studied the skull carefully and then said something to the effect of, "Hm . . .

interesting, but not an ape-man," and left it at that. There is no record of Darwin himself saying anything at all about it. Only one lone voice, that of Professor King, way off in a university in Ireland, spoke up for the possibility that this might be a distinctive earlier species of man.

The truth of the matter is, everyone was so interested in the question of a missing link that no one was interested in anything *less* than that. This skull just wasn't different enough, apelike enough, to seem really significant.

But Neanderthal man couldn't be brushed aside as an accident or a freak. More and more individuals kept turning up, and they were all very much alike. Neanderthal man really did have a heavy face with bulging brows, a low forehead and a receding chin, just as we usually picture him. His neck muscles were so heavy he had no visible neck to speak of. His arms were long, his body short, and he walked with his knees bent. This all sounds very primitive and apelike. But Neanderthal man was no ape-man. He was far too human for that. He was well within the human camp, but with a difference.

His head, for example, was not as neatly rounded as our heads are today. It had back ridges and bulges over the eyes, it was flatter on top, and the back stuck out in what has been called a "bun." His teeth were large, but he did not have long piercing apelike canines. His jaw was large, and thrust forward, and he had no chin, but neither did he have a bony shelf inside his jaw as the apes do.

The final mark of the human status of his head was its size. It was quite as large as that of a modern man. Even though Neanderthal man was a lowbrow, with a flat forehead, he had

plenty of room for brains. The average size of his head was actually a little more than 1500 cubic centimeters, which is about what we muster today.

The question is, though, does the flattened front part of his brain mean that there was some difference in the quality of his intelligence? This is the region where science locates some of the "higher" mental functions. How important is such a difference in shape? There are some American Indian tribes that bind up the heads of their babies so as to flatten their foreheads. This makes them look very odd, and changes the shape of their heads completely, but it doesn't interfere with the way their brains work. Was the brain of Neanderthal man essentially the same as ours too, just squeezed into a somewhat different container? Or was its actual structure somewhat different?

It is possible to make a surprisingly detailed study of the brain from casts of the inside of the skull. Of course, the skull isn't the brain itself; it is only the protective housing. But as an individual grows, and the skullcap grows and hardens, the growing brain leaves its impress on the inside surface. It can't show every fine detail, because the brain is covered with several layers of membrane—rather like a cellophane wrapping. But these wrappings fit snugly, and the main brain contours come through and are imprinted on the inside of the skull.

From studies of such brain casts, we can tell that Neanderthal man did indeed have a brain more or less like ours. Of course, modern science isn't like ancient phrenology; it won't attempt to reveal character and attainments from an examination of the brain, so we can't tell whether Neanderthal man could have passed college entrance exams, or even

learned to read and write. But we can say that the area where the speech centre is located was well developed. Even though he had no chin, Neanderthal man must have been able to talk, and to talk sense.

The way he lived gives further proof of his human intelligence. We have a good deal of information about his life. The museums have big collections of the stone tools that he made. These are not just the heavy fist hammers and choppers which we find for the first hundreds of thousands of years of the stone-tool record. Neanderthal tools are far more advanced than that. They belong to a period known as the Middle Old Stone Age. It's also called the Mousterian. Mousterian tools are designed for use with a handle. Tying a stone blade onto a wooden handle, or sticking it on with a lump of resin, may not seem a very complicated invention to you; of course it isn't, compared to a power saw. But if you think of trying to make a stone tool with a handle, working only with stone tools, you'll realize it isn't so easy, even after you have the idea. And remember that Neanderthal man had to think of the idea, as well as carry it out.

Neanderthal man also knew the use of fire. He can't be credited with the discovery; that goes further back in human history, as the finds in Asia show. But he'd moved further along in its use. Neanderthal man didn't just leave charred bones behind, like Peking man. He left hearthstones in his cave dwellings. This suggests a settled home with a fireplace. We can easily imagine Neanderthal mothers sitting there to rock their babies, slowly adding bits of fuel to the fire as they cooked the family dinner of game their skillful hunter husbands had bagged.



In some cases, Neanderthal skeletons are found that were not just left to lie where they died, or covered over haphazardly as apes may do with their dead comrades. They were carefully, perhaps reverently laid to rest by their fellows, together with some of their tools and ornaments. Such burials are very significant. They indicate planning and purpose, ideas and traditions. They are beyond the powers of any animal but man.



By now we know more about Neanderthal man than just the shape of his tools and the size of his head. Quite a number of odd bits of other bones have been found. In general size and proportions, he was quite human, though a bit on the short side. The men were probably just over five feet tall, the women a little under. The upper leg bones were a little curved. From detailed study of the leg bones, experts think that he must have had a kind of shambling gait, walking with his knees slightly bent. If you try walking with your knees bent, you'll see the kind of muscle pull it causes. Doing this constantly would affect the ridges for muscle attachment on your legs. Of course, you could get the same kind of pull by walking uphill, but Neanderthal man could hardly have done that all the time. Actually, the ridges show that he walked that way, but we don't know why, nor even whether it was the result or the cause of the slight bone difference. Perhaps when physical anthropologists have done more work on muscle development among our primate relatives, they will find the answer. There is another odd thing about his legs. From a worn spot on one of the lone anklebones that has been found, it looks as though Neanderthal man spent a great deal of time squatting down with his legs crossed! On the whole, though, his feet, his hips, and his arms and hands were fully human.

What about his skin? Of course, we don't know whether these early Europeans were dark or light skinned. Under their hairy skins, primates come both ways. There are even dark- and light-skinned varieties or races of chimpanzees. Did Neanderthal man have a hairy coat? Probably not. But we can only tell that indirectly, by his general humanness,

and by the fact that he lived in caves, used fire, and made tools that seem designed for scraping animal skins. Apparently his own skin was not hairy enough to keep him warm as the last of the glaciers began to move southward, and the weather in Europe grew colder.

And so from all this evidence we begin to get a picture of Neanderthal man with his stooping, stocky build, heavy jaw, and sloping forehead living a crude but fairly human hunting life, retreating to the caves, building fires to keep warm, and clothing himself in animal skins as the cold of the last great glacier began to descend upon Europe. In both his life and his appearance he was a crude, perhaps somewhat brutish, but none the less humanlike variant of ourselves.

And then suddenly, dramatically, Neanderthal man disappears from the European scene, and in his place there are to be found only the skeletons of fully modern men, people exactly like us in all the details of their bony structure, with neatly rounded heads, high foreheads, smooth brows, and definite chins. They were tall, robust people who made better stone tools than Neanderthal man and decorated their cave walls with vivid paintings of animals.

What had happened? Where did Neanderthal man come from in the first place—and where did he disappear to? Were the modern-style Europeans who replaced him his descendants, or his conquerors? And just where does he fit into the picture of our ancestry?

Up to about 1929, there seemed to be a fairly standard answer that fitted the facts. Somehow, in Europe, from the

earlier giant- or large-jawed Heidelberg men a special kind of manlike form had developed. This was Neanderthal man; he was a kind of remote cousin of ours, many times removed; a somewhat different and less successful product of nature's attempts to evolve a man. Meanwhile, in some other part of the world, a true man was developing independently, and he was turning out rather better. In the end, during the latter days of the ice ages, this *Homo sapiens* form moved into Europe, and there wiped out the lesser Neanderthal breed he found already in possession. He not only killed him off; there is even an occasional hint that he ate him up—at least some of him. For there are charred Neanderthal leg bones that have been split lengthwise in the human way for their marrow.

In this view, Neanderthal man and *Homo sapiens* are definitely distinct species, separately evolved. They did not mix or mingle, because they were too distinct.

Some of this account still stands today. But some of it has been changed pretty drastically because of fresh discoveries made during the last twenty-five years.

Back in 1929, in Palestine, two sites were being excavated that were called romantically the Oven and the Cave of the Kids. The archaeologists digging there, looking for the beginnings of history, found something that went much further back. For in these caves they found a large number of skeletons of very early men. (Of course, you know by now that in this connection a large number doesn't mean hundreds; it just means ten or a dozen.) The interesting thing about these skeletons is that some of them were rather like Neanderthal man, and yet in some ways far more like us

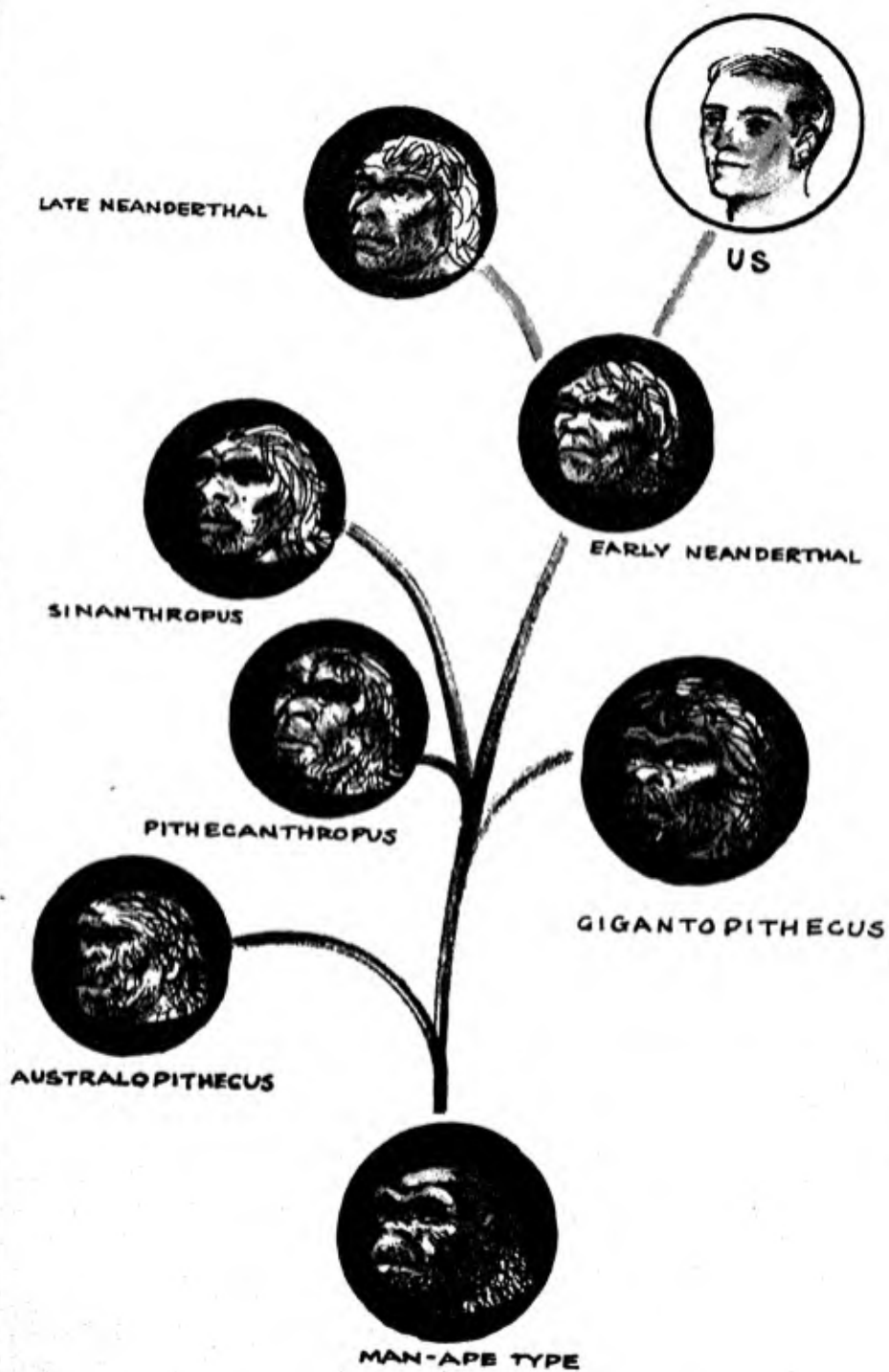
than any Neanderthal man was supposed to be. They didn't have quite such bulging brows, nor such low flat skulls as the typical Neanderthal heads. They didn't have "buns" in back. There were tiny differences in parts of the face, too.

Who were these in-between creatures?

Were they some sort of mixture of Neanderthal man and Homo sapiens? If so, Neanderthal man must be a closer relative than had been suspected.

Or were they something even more surprising? Could it be that they were in-between forms that were developing into Homo sapiens from Neanderthal ancestors? This view is beginning to be widely accepted today, although it is certainly not yet proven.

According to this view, the modern type of man grew out of a Neanderthal type of ancestor, but not in Europe. There wasn't time enough, in Europe. For one species or variety to develop into another, the biologist tells us, takes a long time. It is a gradual process, not a sudden one. Such changes have to affect a whole population, not just one individual or one family. The biologist has seen it happen to the horse, whose past has left a fairly full account in the fossil record. As you know, the horse was a tiny four-toed creature, once upon a time. The changes that came about took place gradually in ancient times and that is how we find their traces among the fossil horse ancestors. First a few individuals of the new type turn up; slowly they grow more numerous in the population; then they almost replace the earlier form. A few stragglers remain for quite a while, and then they too disappear. This happened as four toes became three, and then again as the modern hoof took shape.



Nothing like this took place among early men in Europe. There were no in-between forms, no mixed populations made up of some of each type. Neanderthal man just disappears completely, quite suddenly, and is replaced by modern man. And there is only one way that could have happened—by migration. *Homo sapiens*, in a fully modern form, came into Europe and wiped out the Neanderthal men who lived there. He may not actually have killed off all the population directly; there are other ways one group can replace another. Perhaps Neanderthal man was just driven from the better hunting grounds, so that he starved to death. Perhaps the newcomer was equipped with better weapons and clothing, so that he could survive in the face of growing cold, while Neanderthal man could not. Perhaps *Homo sapiens* brought in new diseases, just as European settlers in modern times brought tuberculosis and measles to native populations in other parts of the world, killing off vast numbers because they had no resistance to these new diseases. In any case, fully modern *Homo sapiens* proved his biological fitness by surviving, and replacing Neanderthal man.

This appears to rule out a European Neanderthal ancestor. But it doesn't prove anything about the rest of the world. And we know now that there were forms something like Neanderthal man in almost all parts of the Old World. There is Rhodesian man, dug up accidentally in a limestone cave in 1925, and then—same old story—buried in a museum for more than five years. He isn't exactly like Neanderthal man. The bulges over his eyebrows are even bigger, and so is his jaw. His jaw is so big it classes him with one of the almost giant forms. But on the whole he is a great

deal like Neanderthal man. And there are other Neanderthal-like forms in Africa, and some in Asia, too. Perhaps in one of these regions there was time enough for an early Neanderthal man to develop into *Homo sapiens*, as indeed he may have done right there in Palestine.

The Palestine find throws light on something else that hadn't been noticed before. The European Neanderthals weren't all exactly alike, after all. The "classical" type we have described was the most usual. But he seems to have been a late-model Neanderthal rather than an early one. There were some earlier Neanderthal men in Europe who were a little bit different. Not, as you might expect, more apelike and primitive, but instead much more like us! This suggests that the more familiar Neanderthal men were a special local variety, who were busy growing their heavy faces and long, low skulls in Europe while their brothers elsewhere were developing into us. If so, the "classical" Neanderthal men would not be our grandfathers. They would be "black sheep" uncles, grown odd in appearance because they were isolated, just as black sheep uncles in ordinary life grow odd and crotchety in character if they are isolated. But other Neanderthal men, in Europe or elsewhere, might be in a direct line leading to us.

How can we decide? We can't, just yet. There's only one way to find out: more evidence.

13.

MODERN MAN ARRIVES

THE early Europeans who invaded Europe in the last stages of the ice age, driving out Neanderthal man, were modern men exactly like ourselves. No doubt they spoke a strange language, and perhaps they wore strange ornaments and painted their bodies with red and yellow ochre. But they were fully human, and would have seemed no stranger to anyone from today's world than the members of some remote savage tribe to an explorer meeting them for the first time.

The first ancient moderns were discovered in a cave near Cro-Magnon, way back in 1863. When the skeletons were described they were greeted with the familiar chorus of, "I don't believe it." It wasn't that there was anything especially odd about the bones. They weren't odd at all. It was their age that was hard to accept. True, Boucher de Perthes had already pointed out that *someone* must have made the stone tools people kept finding buried in the earth. But many people were not yet convinced; they just didn't believe in ice-age men.

But the doubts couldn't last very long. More and more

specimens of men who had lived during the ice ages kept turning up, until by 1900 there were skeletons or parts of skeletons of about eighty such individuals in the fossil warehouse. And the harvest has kept on increasing.

These ice-age Europeans, who lived in the shadows of the glaciers, invented new ways of working stone and bone and wood, so that life became safer and more comfortable. They made efficient stone-tipped weapons for hunting wild game, and sharp knives to skin their kill and cut it up. They had stone lamps for burning oil, and bone harpoons. Some of them painted wonderful hunting scenes on the walls of their caves. And toward the end of the glacial period they had made one of the greatest inventions in all of human history, an effective bow and arrow.

The early European artists drew wonderful realistic portraits of the animals of their day on the walls of sheltered caves. We can study and admire them still today. Unfortunately, though, we cannot learn from these pictures what the artists themselves looked like. People just aren't drawn in the same way. They are more like little stick figures. The only ones drawn in greater detail seem to be priests engaged in ceremonial. They are so disguised in animal masks that their faces don't show at all.

Because these pictures don't show us what the people of those days looked like, we still have to rely on just the bones. We know that the men of Cro-Magnon were robust and heavy boned. They were fully six feet tall, with big heads and large faces, and the women were only a little smaller and less rugged. They were built rather like the ancient Vikings, so much like them that it is hard not to



imagine them with red-gold hair and beards. But, of course, we really don't know anything at all about the colour of their hair, nor about the colour of their skin. Perhaps the genes for blondness that later came to characterize much of Europe's population had not yet appeared, or at least not yet become established in any population.

Men were different from each other in those days, just as they are today. Not all the many ice-age *Homo sapiens* were exactly like Cro-Magnon man. Some were tall, and some were short, some slight of build, some rugged, and so on. Right in Europe, this time in Italy, two skeletons were found whose bones are delicate and slender. They differ from the rugged men of Cro-Magnon much as the slender oval-faced Spanish and South Italians of today differ from their more rugged neighbours of the north.

There have been ice-age fossil men discovered in other parts of the Old World, too. There is Wadjak man, who resembles modern Australians in some ways, although he was found in Java. This skull was sent to Dubois way back in 1890, but he was so busy looking for *Pithecanthropus*, he paid no attention to it. The Wadjak skull was too modern in its characteristics to interest him. He didn't even tell the world about it till thirty years later. And there is Boskop man, with a large head and small bones, found by a South African farmer who was digging a drainage ditch. And there are many others.

But these skulls, with all their differences, are still basically the same: they are definitely *Homo sapiens*, fully modern men. Then as now there were differences between people, but they all fell within the boundaries of one human kind. They were all different in quite definite ways from our Neanderthal uncles (or cousins, or great-great-grandfathers).

If we were just to list the many differences between even the most "modern" Neanderthal men and ourselves, the list would be a long one. We have less jaw and more chin,

smaller eyebrows and higher foreheads, small differences in our cheekbones, the shape of our eyes, the bulge of bone beneath our ears, and so on. Our heads have become higher on top and better balanced, and our faces smaller and smoother. (Actually, our heads are not perfectly balanced even yet. That's why your head nods when you are tired. The muscles in your neck relax, your head droops, and your teacher can tell that you are dozing off!)

But these differences aren't nearly as numerous and complicated as they sound, because they really aren't all separate and distinct. Many of them are just different aspects of one and the same thing. And that one thing is quite simple. It can be summed up in one word—youthfulness.

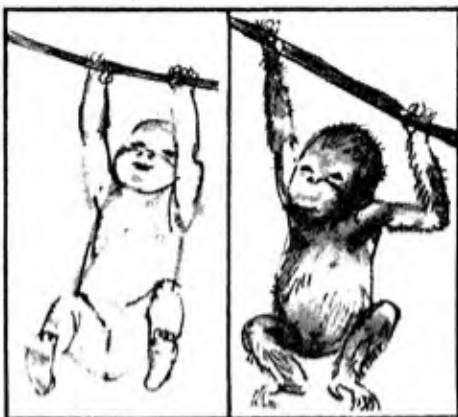
Remember when we talked of *Australopithecus* we said that men were in some ways like baby apes? Men and apes are very much alike just before they are born and while they are infants. Apes change as they grow up, while man remains hairless, small faced, and very large headed. Our heads continue to grow even long after birth, while the apes' reach adult size quickly and then begin to change in other ways. The jaw region is small at first, while the animal is still a nursing baby. But as this stage in his growth passes, the jaw grows thicker and heavier. The whole head begins to hang forward. The muscles grow bigger and crests of bone grow up to take care of them. Even the opening for the spinal cord is shifted back a little, to the distinctive ape position we talked about earlier.

The human face is smooth and straight, like the face of the baby ape. But our face stays that way when we grow up. There is no sharp change, even at adolescence. As domesti-

cated animals, we do not need great teeth and jaws, for our food is cooked, and we use weapons instead of our teeth for protection. We lose some of our baby look—boys change a little more than girls do—but our jaws stay small, our faces smooth, and our heads keep the high-vaulted look of the baby head right into adult years.

At first this idea that we are babylike compared to the apes—and even to Neanderthal man—may seem rather shocking. Really, it is very useful. Staying young longer has many important advantages. Ape babies learn to walk when they are a few months old, and they are pretty independent by the time they are a year old. That's a long time compared to many other animals, but it's much less than in man. As infants we depend on our mothers for more than a year. Even afterwards, when we can eat ordinary food and run about, we are still completely dependent socially. Years pass before we are able to make our own way in the world. But along with this longer dependence goes a much longer period in which to *learn*. Instead of coming equipped with ready-built habits for doing things, man has to learn from his elders how to walk and talk and take care of himself. And because he has a long time to learn it in, he can learn a lot.

Ice-age *Homo sapiens* already has the baby face, the



As babies we and our great ape cousins are very much alike.

small jaw, the round head that we have. He too must have had a long sheltered babyhood, and had time to learn human ways from his parents. Even Neanderthal man lived by human ways, and depended upon learning. Because of their long childhood our close ancestors could carry this even further. They were able to work out, and hand on from one generation to the next, ways of living and working good enough so that they could survive and multiply, and then as time passed, push on to more and more parts of the world.

If modern man was already spread over so much of the globe and already so varied by the late ice ages, his beginnings must lie further back in time. But we don't know yet just when this happened, nor where.

The finds in Palestine didn't answer all our questions. For one thing it isn't certain whether they were Neanderthal men becoming human, or just Neanderthals mixing with humans already developed somewhere else. So we still have to look around for the possible somewhere else.

Even if we were sure that some modern man did develop right there, among the people who buried their dead in the Oven and the Cave of the Kids, we would still have to go on searching. For after all, we are not looking for a single place where one man first became human, and so fathered the whole humanity. Just one individual becoming fully "modern human" would have been swamped in a whole world population that was different. Man's birth was quite a different kind of event. It was a long, slow, gradual process. It was the transformation of a whole population by the slow spreading through it of genes for modern human

traits. Whatever the causes were that brought these gene changes about, they must have operated over and over again in many people, not just once in one person or family. For the entire human population of the world to become *Homo sapiens* this process must have gone on repeatedly over what Weidenreich calls a "wide surface of evolution."

This area in which an almost human population turned fully human cannot have been anywhere in America. There just wasn't anything there for *Homo sapiens* to develop from. There were no early manlike forms; there weren't even any closely related primates, only the quite distinct line of wide-nosed South American monkeys. It seems quite certain that all Americans are immigrants, even the ones who were there long before Columbus, though some of them came there as much as twenty-five thousand years ago.

There has been a lot of argument about that date. For a while a much more recent date was popular, but the discovery of mastodons killed by human arrowheads has pushed it back; it rules out a mere ten thousand years as much too recent. However, nothing has pushed the date back beyond the twenty-five-thousand-year mark. That has geography on its side: it was a time when the passage to Asia could be made comfortably over the ice. And it has lots of arguments from history—prehistory, that is. There are no traces of Americans earlier than that date, not even in the form of tools. Nowhere in America are crude early stone tools to be found, only the finished tools and weapons characteristic of the later days of the stone ages. This is very convincing, because stone tools last longer than bones, and are usually

much more numerous. After all, one hunter made many hundreds of chipped-stone tools in his lifetime, while he could leave only one skeleton under even the best conditions!

Of course, many attempts have been made to set man in America far earlier, but they have all failed, though some have stirred up a lot of excitement. One was a crude hoax. The Cardiff giant, widely exhibited in circuses as a "fossil man," was just a large statue buried in the earth in order to be dug up again publicly. One was a very embarrassing mistake. It was a tooth that got a lot of publicity until it became clear that it was not the tooth of a man at all, but of a wild pig. And the other reported finds just haven't ever proved to be very old.

As for Europe, we musn't rule it out of our calculations completely. From time to time someone comes up with fresh data that suggest that a very early kind of *Homo sapiens* lived there, even before the day of Neanderthal man—though they aren't quite prepared to say what became of him later.

There is a big dispute just now over a very early Englishwoman known more formally as the Swanscombe skull. There isn't a skull, really; there are just two pieces of bone from the back and one side of the head. And this just isn't enough to settle her anatomical status, though it is enough to determine that she was female, and quite ancient—considerably older than Cro-Magnon man. (If it surprises you to think of an early form here on our island, remote from the main continent where we would expect more things to happen, remember that in those days England wasn't an

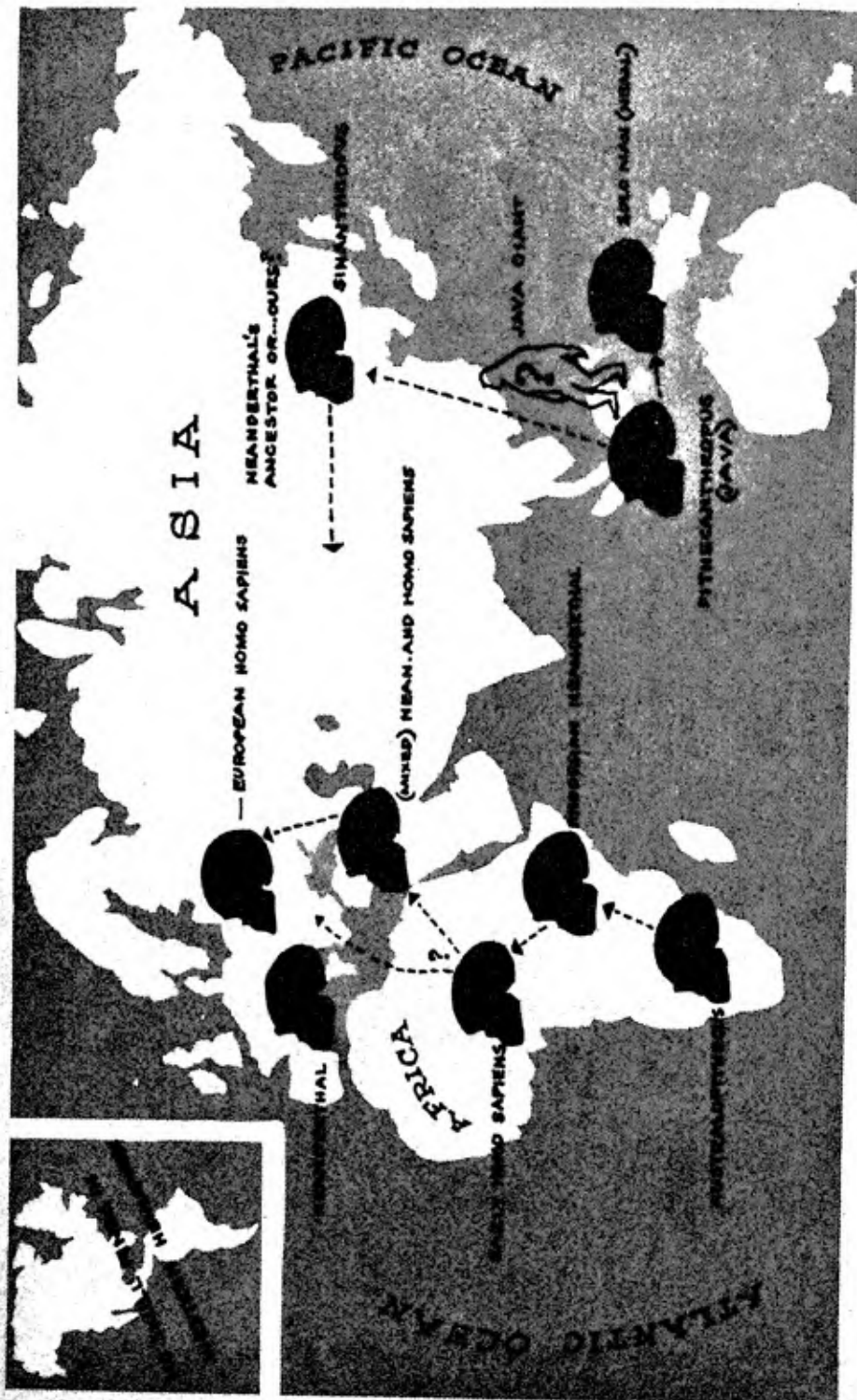
island at all. This Englishwoman could easily have walked dryshod from France.)

There has been a great deal of speculation about this lady, in spite of the skimpiness of the evidence. Or maybe because of it, since it can allow a wide range of "maybe this is how it was" answers. We know that she lost her life by "a blow from a blunt instrument." But it would be idle detective-story fiction to discuss whether it was her husband or an enemy raider who wielded the cudgel. And it is nearly as fictional to try to declare her our great-great-grandmother, until more evidence turns up. From the evidence at hand, she could equally well be an early Neanderthal lady.

What about the rest of the Old World? Can we locate man's homeland definitely in Asia or Africa? Certainly early not-quite-human creatures lived in both. The final answer isn't in yet, but the spotlight of interest is turning to Africa nowadays.

This is partly because of the new position of *Australopithecus* as a respectable member of fossil society. There are lots of other reasons, too. There are many hopeful-looking places in Africa that have not yet been dug in at all. And there is plenty of evidence from tool remains that man lived in Africa way back to the days when he was making stone tools of the very simplest types.

In addition, some tantalizing early *Homo sapiens* fossils have already turned up. Professor Leakey, who has headed several expeditions into East Africa, claims that one of his skeletons from Kenya is really very old, several times older than any other early human fossil. But other experts are



doubtful about this. And Oakley was unable to settle the question when he went to Africa to apply his fluorine techniques to these African fossils.

The problem in dating African fossils, whether they are *Homo sapiens* or *Australopithecus*, is that the glaciers, our most valuable time clock for the million years of the Age of Man, never moved down over Africa.

Geologists would like to be able to match the movements of the glaciers in Europe with changes in the climate in Africa. During the periods when the earth was very cold the water level of the oceans dropped because a great deal of the earth's moisture was stored away in the glaciers. During warm interglacial periods the climate was damp, and the floodwaters rose. There is evidence of such alternating wet and dry periods in parts of the world where the glaciers themselves did not reach, including Africa. It is by such indications that Leakey sets an early date for his African skeleton, for it was alive when the earth was warm and wet, the level of the great African lakes high. Was this the interglacial period during which Neanderthal man was established in Europe or some other warm, wet time? An earlier interglacial? A later one, purely local? The problems are great enough, but they sound like the kind that can eventually be solved.

Meanwhile, Leakey is pinning his hopes to the site he has now been working for a number of years. The scene is a deep gorge in Tanganyika called the Oldovai Valley. Here stone tools have been found that go all the way back to the very simplest beginnings, one layer of human living giving way gradually to another. Apparently, in this one region in

This map shows where some of our early ancestors were found. The dotted lines suggest some of the possible directions of man's development.

Africa man has lived continuously from the earliest times to the present. So far Professor Leakey has not found bone remains, but there are parts of the gorge still to be explored that may be more rewarding. The layers are wonderfully undisturbed by man or nature. Here one day Leakey hopes to find remains that will settle our questions definitely: remains of earlier forms of man giving way by gradual stages to full *Homo sapiens*, with the steps in the process written clearly in the bones and in the arrangement of the rock layers they are buried in.

It is a pretty grandiose hope, but other hopeful fossil hunters, given time and lots of patient work, have had their dreams rewarded. Perhaps one day his will be, too. Then we shall see in the papers, "Garden of Eden Discovered in Africa" . . . and you will be able to read the article carefully and see whether indeed our earliest grandfather was a Neanderthal man of some sort, or came by a somewhat different route from a form like *Australopithecus*.

14.

AND NOW WHAT?

WITH all this evidence now in, just how does our jigsaw puzzle shape up?

There are obviously lots of gaps still. But the main outlines have emerged by now.

Some millions of years ago, long before the ice ages began, our ancestors came to an important parting of the ways. Leaving their ape cousins to pursue their own course in the forests, our ancestors stepped out in a new direction, onto the open ground. Their primate ancestors had contributed sharp eyes and a giant brain, flexible hands, broad shoulders, and a nearly erect posture to their development. Now they had to work out some further improvements—a foot that could support a giant body without the help of arms or a tree limb to hang by, body muscles strong enough to maintain upright balance, hips and spine adjusted to upright posture so that the soft inside parts would have some support in this new position, a better balanced head. Of course, they didn't have these set out as a problem to be solved by blueprints. But they were problems in engineering nonetheless. These things had to be achieved if a ground-living ape was to survive.

Over the years these adjustments were all made, maybe not always perfectly. Posture, for example, remains a problem with us today. The correct position for your spine is a kind of an S, but that curve isn't actually built in. It has to be developed by each child as he slowly learns to sit up, and later to walk. As we grow older, many of us carry the thing too far, so that our whole back sags. And, of course, many of us lose the springy arch in our feet, and have a great deal of trouble with "flat feet."

But basically the job has been done, and most of it way back in the days when ancestors of ours like *Australopithecus* first learned to walk erect. When the hands of our long-ago ancestor were freed from any task in locomotion, the rest of man's development could follow. As brains grew better, tools took over the tasks of food-getting and protection. Jaws and teeth grew less massive, the muscles that move and support the jaw grew smaller, the skull became less musclebound, and there was room for still further brain expansion. Neanderthal man had a brain grown to full human size, and a more or less human face. And modern man went further. The period of his babyhood grew longer, his head became more nearly a smooth round globe, and his brain continued to grow long after birth.

Fifty thousand years ago, all these main steps had been taken. We had arrived. We were human beings, upright, baby-faced primates, who depended on our brains, on skills that we could learn rather than on inborn habits, more than any other animal before us had ever done.

These beginnings took place not just in one place but over a wide surface of evolution which may have been a

large area in Asia or in Africa, or perhaps in parts of both. Once our ancestors developed into truly human beings, they began to spread out over the rest of the globe. Because of their brains, their ability to learn new ways, they were freed from the usual animal bondage to one kind of food supply, and one kind of climate. They were free to learn new ways of getting a living. And from the beginning, they availed themselves of this freedom. Cro-Magnon man moved into Europe early; he was followed by some invading Asiatics whom we know only by the superior spearheads they made and left behind them. Man spread out over all the Old World. As the years passed, he made his way along the shores of the Indian Ocean, and out across the islands of the Pacific, to reach Australia. And finally, in many small migrations from Asia he peopled both the Americas. By the beginning of "modern" times, men had reached the limits of the habitable world.

The people of various parts of the world came to differ from each other somewhat as time passed. If we look back a few thousand years, we find certain traits common in different parts of the world. The people who were living in America and eastern Asia had brownish skins and straight black hair. Some of them had broad faces, high padded cheekbones, and a skin fold in the upper eyelid that gave their eyes a "slant-eyed" or "almond-eyed" look. In Africa many of the people were much darker. They had very short curly hair. The people in Europe were oddest of all. They were not only more light skinned than was usual in any other part of the world, but they had even come to have blond or reddish hair and blue eyes!

We don't know how far back in human history these patterns go. Even when the fossil record grows fuller, it is not likely to tell us about hairiness or eye colour. We already know that there were differences in height, in face shape, in nose size, and so on, in early human days. But we don't know how they were distributed among people. They may just have been differences between individuals and families, rather than characteristics of early "races."

There is, for example, one famous grave that was discovered in the very caves where Peking man once lived. The ancient skeletons in that grave are the remains of an old man and two women, one old, one much younger. Perhaps some ancient chieftain was buried there with his wives to keep him company, a practice many peoples have engaged in to honour their leaders and assure them companionship in the life to come. The odd thing about these skeletons is that they are not at all alike. They have traits that are nowadays more often found among Melanesians and among Eskimos, as well as a tooth shape that is still common in that part of Asia.

There were always some differences between people. And when small groups settled down for a while and became cut off from other parts of the world to some extent, they did develop group peculiarities. They could not draw on the common stock of human variations but only on the ones that belonged to their own particular founding fathers. If they just happened to have more snub noses or freckles or longer heel bones than usual, these became the rule among their descendants. Biologists have a name for this kind of accidental difference that grows up in a local population.

They call it "genetic drift." Sometimes selection may have played a role, as in helping the flat face of the Eskimo—a good adjustment to Arctic cold—or the white skin of the European (more reaction to sunshine vitamin D?) to get a good start. But biologists aren't quite sure of the importance of selection in developing human local types. It takes a long time for selection to work, and human populations just don't stay put long enough!

One thing is certainly very clear. The various traits that did become characteristic of the populations of different regions were never special inventions limited to just those populations. Straight and curly hair, black and blond hair, the various different blood group factors, and all the other known human hereditary traits appear in all parts of the world, though in somewhat different proportions.

Some of this is due to new mutations which keep occurring today just as they did in the past. We don't really know enough about the gene factors for skin colour or hair form to point to definite instances, but we know it is true of traits whose heredity we understand better. Hemophilia, for example, the strange hereditary disease that involves failure of the blood to clot when exposed to air, crops up suddenly in families with absolutely no past history for this trouble. An individual in that family, without any reason that we know about, suddenly produces a new mutation for hemophilia. Once it appears, it behaves as a normal hereditary trait. That, it seems, is precisely what happened to Queen Victoria herself, for a certain number of her descendants have this condition, though it was not noticed in any of her ancestors.

Different traits crop up repeatedly in this way in different populations. They also spread from one population to another. No human populations are ever entirely cut off from their neighbours, though some have been isolated enough to become pretty distinctive. The little kinky-haired, sandy-skinned Bushmen of South Africa intermarry with their Hottentot neighbours, and they in turn with the Bantu peoples of the region. Thus the Bushman variations are spread among other peoples, and the traits of the latter in turn absorbed by the Bushman. The Australian aborigines mingled somewhat with their Melanesian neighbours across the Torres Strait, and the Eskimos with their Indian neighbours in Canada and their Chukchi neighbours in Siberia (to say nothing of an occasional Viking explorer).

Throughout history, between neighbours and in great migrations, people have mixed and mingled their hereditary traits. You know of some of the population shake-ups that have taken place in modern times, let us say since the time of Columbus. North America today is peopled more by descendants of Europeans and Africans than by the Indians who came here a little earlier. The same kinds of things happened in classical times, in the days of the Greeks and the Romans and the Persians, and they happened in Biblical times, though perhaps a little more slowly and on a smaller scale. In medieval times the Arabs swept into Europe, and the Mongols under Genghis Khan reached China and Persia and eastern Europe. So it goes, on and on and on, all the way back to Cro-Magnon man's entry into Europe, and even farther back than that.

As a result of all this, all gene variations, ancient or new,



All the peoples of the world are kin to one another.

have spread to some extent to all peoples. In spite of the local variations that have arisen from time to time, mankind has remained what the biologist calls "a single breeding population." There are no sharply different breeds of men.

In this respect man differs from most other animals, which tend to develop clear local varieties. They develop specialized forms suited to different conditions—the striped tiger lives in the jungle and the tawny lion in the desert. Man, however, remains flexible, with just small variations within one basic human form, the same in its essentials and its potentialities all over the world.

This has been an important factor in our biological success. For man is a very successful form, biologically, as fishes were once upon a time, and dinosaurs in the great Age of Reptiles. There are a great many of us. Two and a half billion right now, and experts say we are increasing at the rate of twenty thousand a day. We live on every bit of land except the Antarctic, and our ships ply the seas and fly the skies. We are now stronger than the lion and fleetier than the horse. We have come close to wiping out many of the other mammals, except for the domesticated animals, which we feed and encourage to multiply so that we can put them to human uses. Only insects and germs offer us any real challenge.

But we have gained this mastery without the specialized growth in different directions that was true of the other successful animals before us. In the Age of Fishes, there were some seventeen thousand different species of fishes. When

the dinosaurs were great, there were many different kinds of dinosaurs, flesh eaters and vegetarians, dinosaurs that walked on four legs, and others that walked on two, or swam in the water, or flew in the sky.

This branching out into many forms is a usual step in evolutionary development. First a generalized form appears. Then it spreads out. Local variations appear, and become adapted to many different kinds of conditions.

The mammals had such a burst of "adaptive radiation" about the same time as the reptiles lost their leadership in the animal world. Carnivores and rodents, grass eaters and primates, all appeared, some sixty million years ago. Each carved out a separate part of nature for its home, and made use of different parts of the available food supply. (Sometimes, of course, this food was each other.) And each of these different kinds of mammals also radiated out into many varied forms. For example, the grass eaters became the fleet horses and giraffes, as well as the sheep and goats, the deer with their useful horns, and the elephants with their heavy skins for protection.

But man has not needed to do this. We have not grown different breeds of humans, geared to speed or strength or skillful fingers. Of course, there are differences between people in all these things, and in intelligence, too, no doubt. But the differences are small, and they are scattered throughout the peoples of the world. They aren't the special qualities of separate kinds of people, like the races of dogs that are suited to particular kinds of hunting, or the different kinds of horses that are grown for farm work or as polo ponies. With time that kind of selection would make men

limited. People would have to lose one set of abilities in order to concentrate on others, just as whales lost their legs when they grew streamlined for swimming, and horses long ago gave up their flexible paws for greater speed and strength in their legs.

Man does not need to specialize in this way, because man has a brand-new way of handling the problem of adjustment. He does not have to try experiments in different kinds of living with his own body, and then stand or fall by the results. He can use things outside his body, and when his tools or inventions are outworn, he can change them, instead of having to change himself. If an animal depends on hoofs for speed, they become his built-in safety device. If they fail, on new territory, or against a swifter enemy, the animal will die out. He is tied to his special achievement. But men can move from wagons and bicycles, powered by muscle, to gas-powered cars, aeroplanes, and on to rocket ships for greater speed, all in the space of a hundred years. As man's brain takes over, it creates and maintains a world of infinite flexibility for man, so that he can produce new adaptations with new speed, without his own physical apparatus having to change at all.

This new freedom comes from the power of man's brain, an achievement of man's evolution over just a small part of the last million years. But it is rooted in man's actual body, with all its wonderful inherited machinery for keeping us alive—hearts and lungs and stomachs and all the rest of our organs that supply us with food for energy and growth, with oxygen to keep the cells of our bodies working, that remove our wastes, and keep our temperature level. Living our lives

as individuals, and producing a new generation to live after us, depends on this old inheritance, on the traits we inherit from our mammal ancestors and from our animal ancestry that goes even further back than that. Man must make his life within the framework of this heritage. He must live in ways that are healthy to maintain his existence as an individual and produce a healthy new generation.

And he must live with the heritage of his primate body, with all its advantages, and all its deficiencies. This primate inheritance accounts for our fingernails as well as our eyes, our annoying appendix as well as our giant brains, our wide shoulders and the imperfections of our upright posture, the powers of observation and memory and the lively curiosity which are an important part of our intelligence.

We cannot predict whether any of these things will change as time passes, whether the mechanisms of our bodies will become more perfectly suited to our needs. Perhaps we will stop growing wisdom teeth in our crowded jaws, or lose our useless little toes, as some have suggested. Perhaps more bottom sections of our spines will fuse to strengthen the hip girdle and give our bodies more support, as happens to some individuals nowadays. But we cannot say for sure.

We can say, though, that man's future does not actually depend on such changes. It depends on what we do with the life we make for ourselves. We are no longer chained to our heredity. We can use science to overcome its shortcomings. And we can use science to learn to live up to our hereditary capacities, to achieve a fuller measure of health and happiness with the endowment we already have.

We do not need to breed people who are stronger, nor

even people who are cleverer. We do not need new brains to build new tools. What we need is to master the tools we already have built, to use them for man's good, rather than his destruction. And we have to learn to live with each other, peacefully and co-operatively, in families, in nations, and over the whole world, if we are to survive at all. This is a task for evolution, for human evolution—evolution in the things we learn to do and teach our children. It does not take new-style bodies and minds to do it. But it may require us to fashion new ideas and new attitudes toward mankind.

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